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March, 1941

Heating · Piping and Air Conditioning

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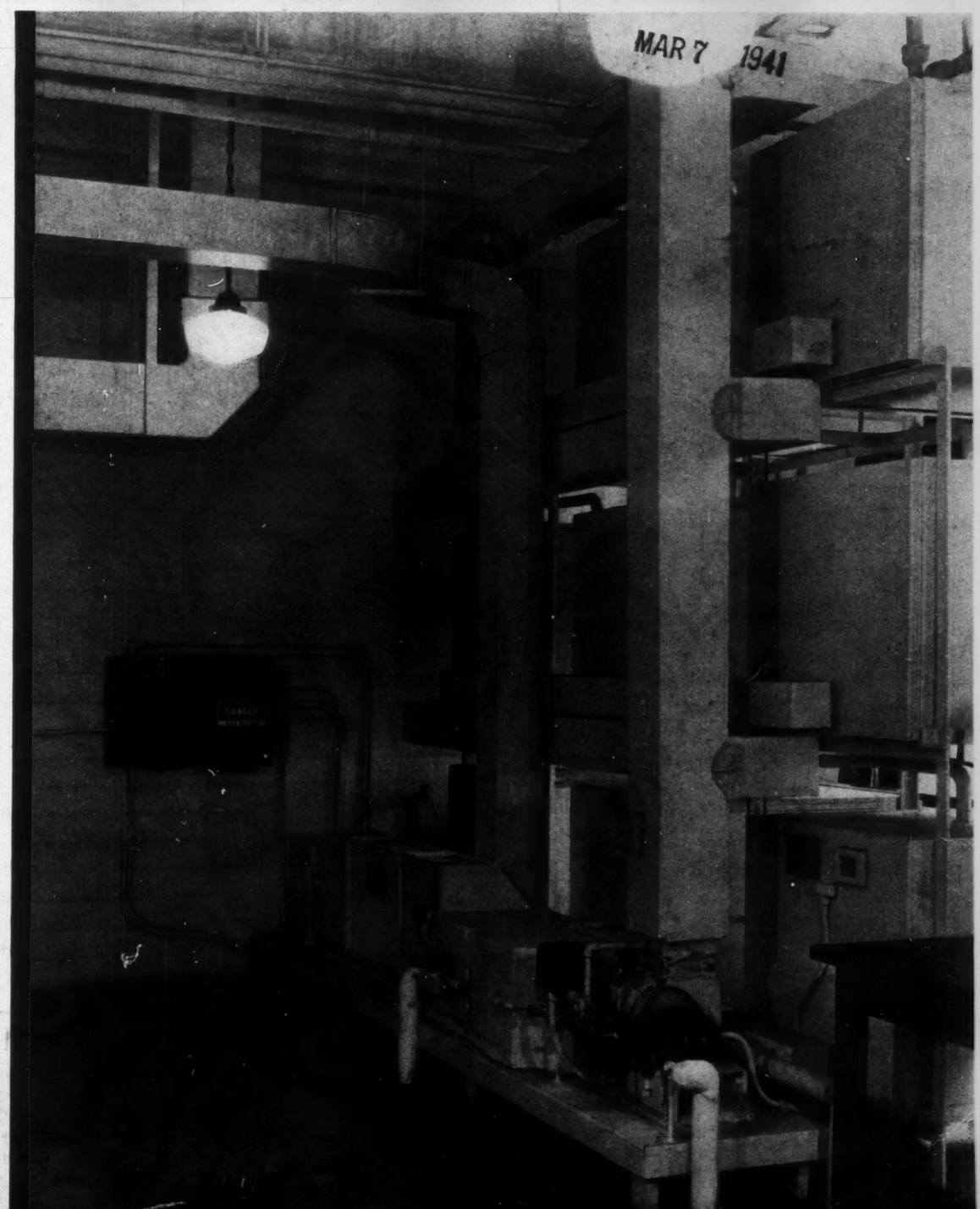
...ercial, Industrial
...Large Buildings



...DUSTRIAL health and ...cupational diseases are ...udied at the Kettering ...aboratory of Applied Phys...logy. The diminutive cen...al station air conditioning ...stem shown here is in...alled to control conditions ... the animal boxes. Total ... circulation is but 207 ...m, ducts are 2 in. in diam...er. See description, p. 149

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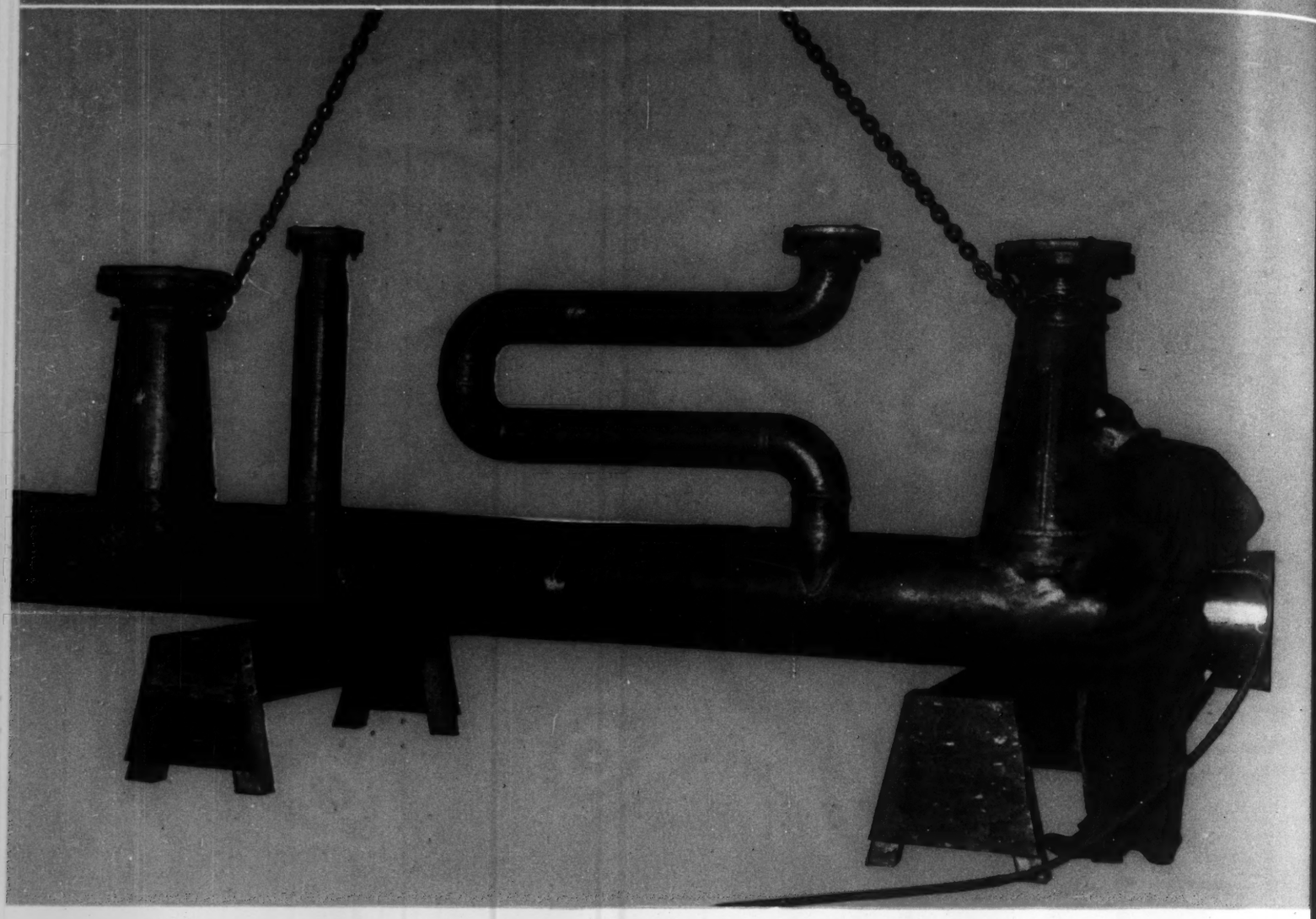
To Help You Meet "TIGHT" EXPANSION SCHEDULES...



Interpretive Engineering by Grinnell may cut weeks from super-piping installation!

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WHENEVER **PIPING** IS INVOLVED

The Editor's Pages

WAR DEPARTMENT APPOINTS EXPERTS

The war department announced last month that some of the most eminent consultants and operators in the American building industry have been appointed to serve as staff executives in the offices of the nine zone constructing quartermasters of the construction division, office of the quartermaster general.

Each zone constructing quartermaster has had assigned to his organization a zone engineer, a zone architect and a zone operations officer, chosen on the basis of their reputations as leading representatives of their respective professions, by the chief of the construction division, with the approval of the quartermaster general.

The zone engineers, architects and operations officers were selected for the consideration of the chief of construction by the construction advisory committee to the army and navy munitions board, composed of the following: J. D. Hogan, chairman; Ernest J. Russell, architectural member; E. P. Palmer, contractor member; Malcolm Pirnie, water supply member and H. E. Foreman, director of the Associated General Contractors of America.

[Note: Names of the zone engineers, architects and operations officers are listed by zones on p. 144, back section, this issue.]

PREDICTS "DISTRICT AIR CONDITIONING"

Dr. Willis H. Carrier, board chairman of the Carrier Corp., recently prophesied possible developments during the next 25 years of air conditioning. Foreseeing even greater applications than it has had in the past, he stated that with its general acceptance we may even expect air conditioning of the future to be operated as a public utility and applied in large units to extensive areas in our largest cities. The air conditioning unit for such a system, according to Dr. Carrier, may include a section comprising 100 blocks or more with its own cooling and heating system—each block having its own air conditioning and ventilating system.

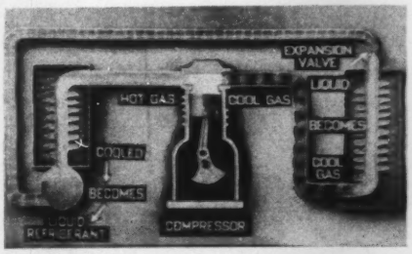
Meters will be invented, he prophesied, which will measure the total amount of heating and cooling service delivered so that occupants of buildings will pay for only what they receive, just as they now pay for electricity or gas. Such a service can be provided at a considerably lower cost and with greater dependability than is possible with present individual air conditioning systems, he stated.

Great overall economies are possible with such a system. Great turbine-driven centrifugal refrigerating machines at the central plant, compact in size, with capacity of probably 50,000 tons each, will be employed. From the central plant, water mains will be run to each and every block. The same mains will distribute warm or cold water as required and, in intermediate seasons, both warm and cold water so that heating or cooling may be obtained at will.

Not only will the buildings be cooled, but buildings in the future will probably be provided with arcades which will be enclosed from the street limited to automotive traffic. There will be overhead enclosed cross-overs from block to block so that a pedestrian may go from store to store and from block to block without ever subjecting himself to the rigors of winter, the torrid heat of summer days, or the hazards of street traffic.

Air cooling in summer will not be overdone. Conditions will be kept reasonably comfortable at considerable economy, but, what is more important, with ideal consideration for health.

Such improvements which are here envisioned will not come at once but may be confidently predicted as the logical development of the near future in an art which has already done so much for human comfort and efficiency, he concluded.



THE REFRIGERATING CYCLE — An illustration from "Weather by Carrier," industrial movie devoted entirely to air conditioning, a 15 min sound film available for club and other educational uses

PHILLIPS BECOMES NDHA HEAD

F. L. Witsell of the Toledo Edison Co., who became president of the National District Heating Association last May, was recently made president and general manager of the Pueblo Gas and Fuel Co., Pueblo, Colo. Because of this transfer, Mr. Witsell resigned as president of the association, and the executive committee regretfully accepted his resignation.

Leonard S. Phillips of the New York Steam Corp., first vice-president of the association, has therefore advanced to the office of president; John M. Arthur, Jr., of the Kansas City Power and Light Co., advanced to first vice-president; and Raymond M. Nee, of the Boston Edison Co., advanced to second vice-president.

MINERAL WOOL GAINS

Mineral wool sales for the third quarter of 1940 registered a 35 per cent gain in dollar volume over the same period of 1939, according to figures announced by Wharton Clay, secretary of the National Mineral Wool Association, at the association's recent annual convention in Cleveland.

Newly elected officers of the asso-

ciation are president, M. L. Kuykendall, Insulating Industries, Inc.; vice-president, E. R. Stevens, Baldwin-Hill Co.; and treasurer, E. I. Williams, Riverton Lime & Stone Co. The new board of directors consists of President Kuykendall; Treasurer Williams; J. R. Addington, American Rock Wool Co.; L. M. Cassidy, Johns-Manville; E. E. Wood, Jr., Therminsul Co.; Alan Hughes, U. S. Gypsum Co.; and G. E. Lortz, Philip Carey Co.

BIG FAN YEAR PREDICTED

At its recent annual meeting in St. Louis, the Propeller Fan Manufacturers Association, 2-255 General Motors Bldg., Detroit, elected E. W. Petersen of American Blower Corp. president, A. R. Stephan of DeBothezat Ventilating Equipment Div. vice-president, and named V. C. Shetler secretary-treasurer.

Insistence on the part of architects, engineers and consumers that fans bear the certified rating label of the association was reported at the meeting. It was also stated that the general public is becoming more and more conscious of the necessity of good ventilation.

The association feels that 1941 will be "the greatest production year in the history of the fan industry" and states that all members are coöperating to the fullest extent to aid in the national defense program, by increasing production to keep pace with increased demand for ventilating fans.

AIR HYGIENE FOUNDATION ELECTS

Dr. H. B. Meller, managing director of the Air Hygiene Foundation of America, Inc., 4400 Fifth Ave., Pittsburgh, Pa., announced last month the election of V. P. Ahearn as secretary of the board of trustees, and of Theodore C. Waters as general counsel. John F. McMahon was promoted to executive secretary.

The foundation is a non-profit organization of industrial concerns for the conservation of employee health throughout industry.

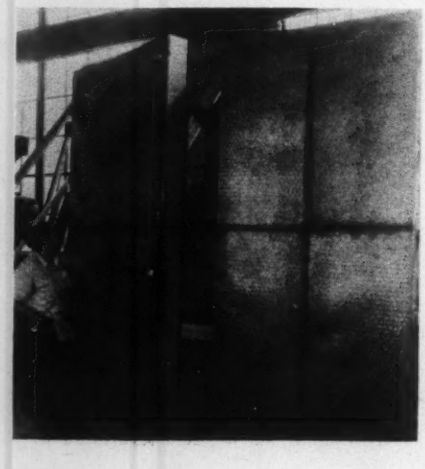
In making his announcement, Dr. Meller declared that the arming of America, demanding new production highs, has served to spur health protection in industry as never before. He warned that increased production increases occupational health hazards and demands increased precautions.

STOKER GROUP NAMES BURNS

The Midwest Stoker Association at its annual meeting held in Chicago on January 28 elected its officers for 1941 and took a rosy view of business prospects for future months. Mount Burns, Link-Belt Co., was chosen president to succeed L. G. Briggs. Other officers re-elected were E. M. May, Combustioneer Div. of Steel Products Engineering Co., vice-president, and E. W. Jones, Iron Fireman Mfg. Co., secretary-treasurer. Marc G. Bluth was reappointed manager of the association.

COLD ROOM FOR TESTING GUNS

This cold storage door, shown here in the shops of the York Ice Machinery Corp., is destined for the Aberdeen Proving Ground at Aberdeen, Md. It is to be used to seal a cold room in the gun testing department. In order to simulate extreme conditions under which the guns might be fired in winter, a huge cold storage room has been built—big enough to house large automotive equipment and guns, with spades (recoil anchors) set for firing. The equipment to be tested passes through this door, which is then closed; the gun is placed in firing position and when the cold room has been reduced to the desired testing temperature, the gun is fired through a special opening in the roof and wall, resembling an astronomical observatory window. Thus recordings of the accuracy and efficiency of the gun mechanism in zero weather can be made



COMFORTABLE CALABOOSE

According to a story in the Washington, D. C., Evening Star last month—sent on by the helpful Air Conditioning & Refrigerating Machinery Association, whose headquarters are in that city—the capital city's new second precinct police station features — among other things—complete air conditioning. Primarily designed for the comfort and efficiency of police at work, the "guests" also enjoy the blessings of air conditioning in their cells.

HOUSING OUR CITIZEN ARMY

Since early last fall, a fund of approximately one billion, one hundred million dollars has been made available for the temporary emergency construction program by the Congress. About three-fourths of this amount is going into troop housing and the rest into the construction of storage and production plants, according to Brigadier General Brehon Somervell at the annual convention of the Associated General Contractors of America last month.

Compared with the construction program of World War days, it is in many ways more varied and extensive. Planning is better, construction is better, equipment is better, design is better, he said. Increased attention is being given to the elements of comfort and safety in the erection of troop shelter and accommodations.

WE HEAR THAT . . . .

Sarco Co., Inc., formerly at 183 Madison Ave., manufacturers of steam specialties, announce the removal of their head offices on March 1, to 475 5th Ave., New York, N. Y., where they occupy the entire 24th floor.

* * *

Roy H. Warmee has been appointed sales promotion manager of Minneapolis - Honeywell Regulator Co., with headquarters in Minneapolis, according to C. B. Sweatt, vice-president in charge of sales.

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with which is merged the "Aerologist"

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Operation • Maintenance

Commercial, Industrial
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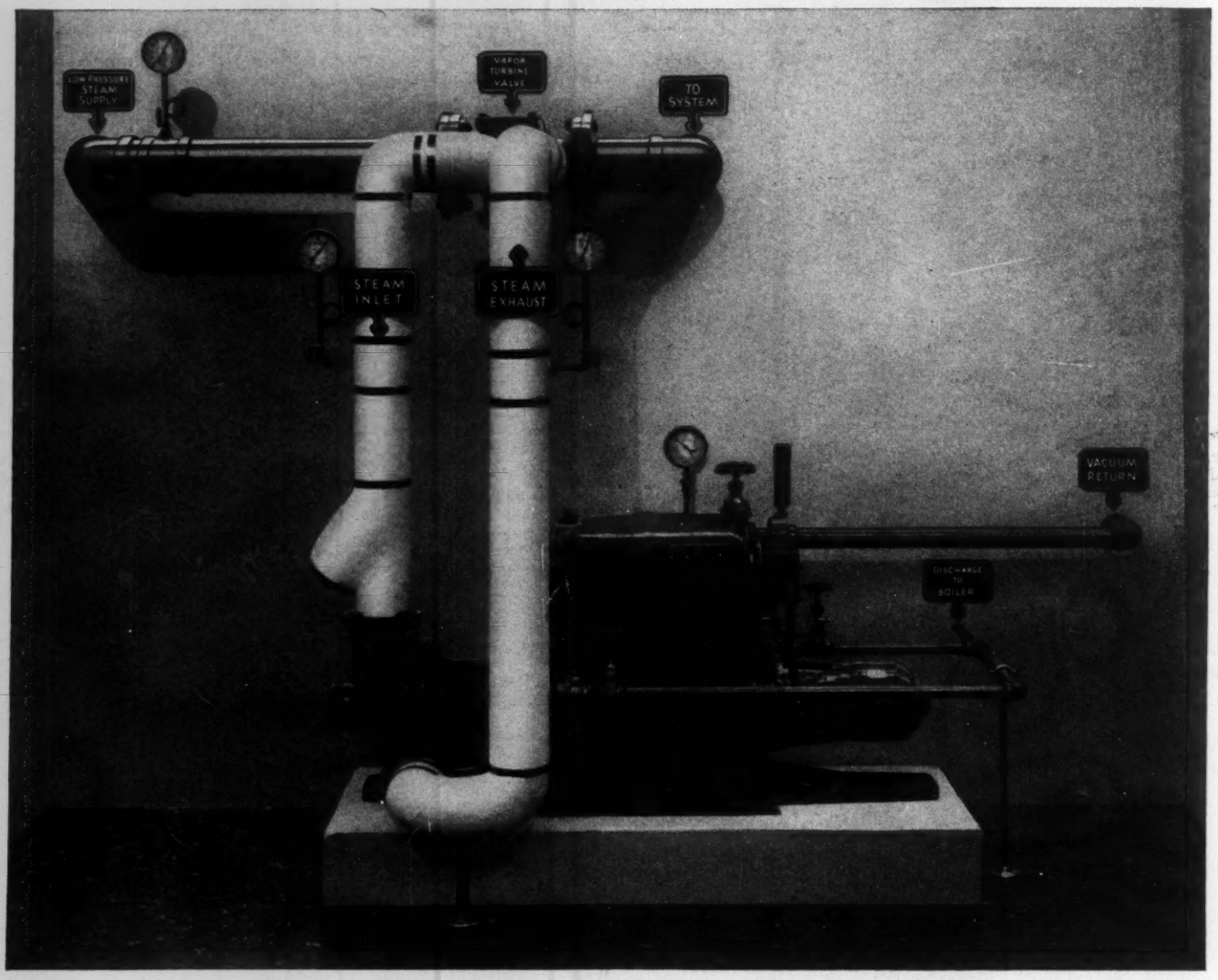
Where Heat Must Not Fail— Install this SAFE Heating Pump!

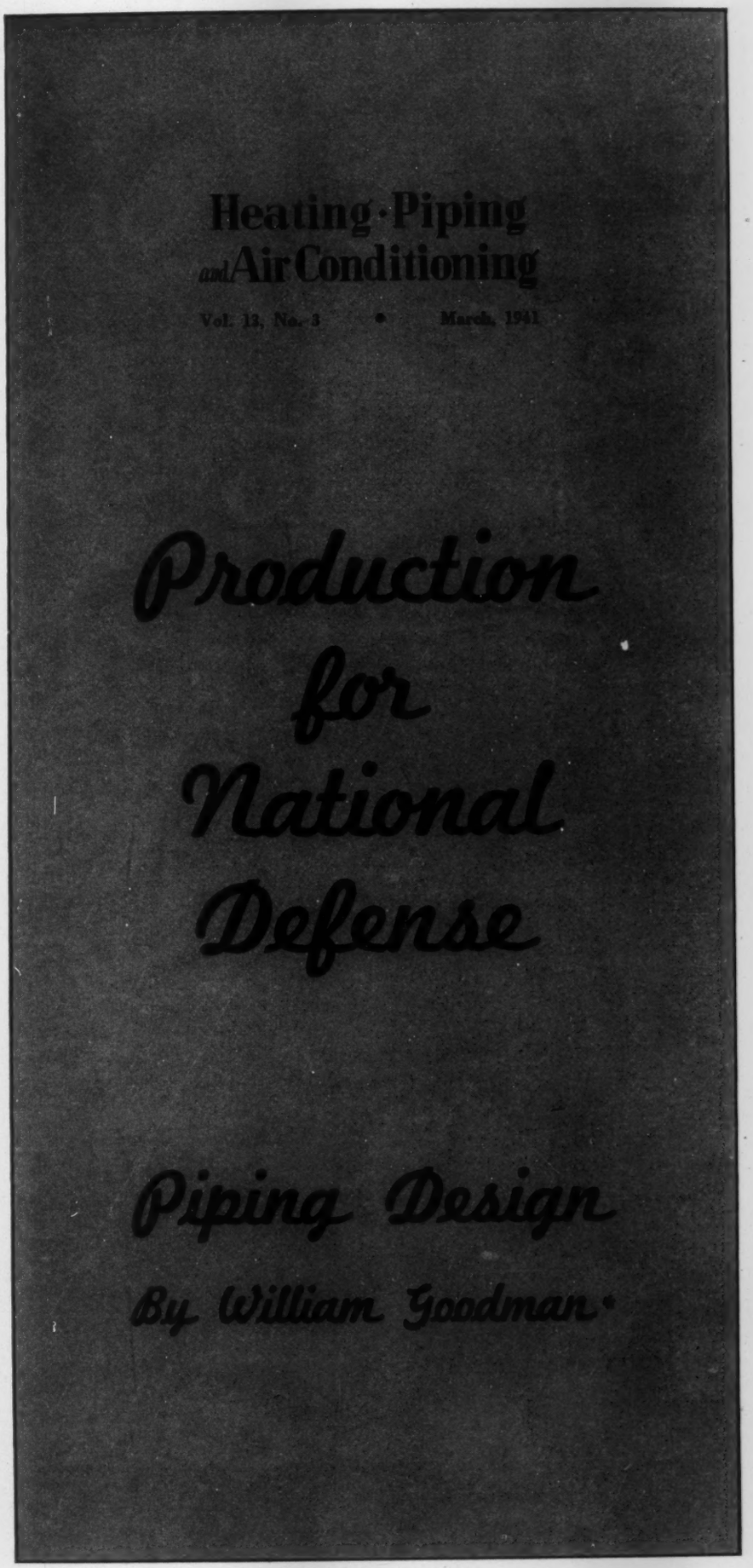


In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY
205-A WILSON ROAD, SOUTH NORWALK, CONNECTICUT, U. S. A.



THE flow of gases and vapors through pipe lines is computed in exactly the same manner as the flow of liquids as long as the total drop in pressure is small. For a small drop in pressure the change in density is small and may be neglected. On the other hand, if the drop in pressure is large, the change in the density of the gas may not be neglected. In this case, the change in density will have a large effect on the flow.

Flow of Gases and Vapors with Large Pressure Drops

The equations needed to handle flow problems involving large changes in pressure and density were presented in two earlier articles [HPAC, October, 1937, p. 625, and November, 1937, p. 689.] In this article the use of the universal flow chart presented on p. 604 of the October, 1940, HPAC, and republished as a data sheet on p. 156, this month, will be discussed in connection with the solution of such problems. The use of this chart greatly facilitates the solution of problems in fluid flow and eliminates considerable arithmetical work.

*Consulting Engineer, The Trane Co. Member of HPAC's Board of Consulting and Contributing Editors.
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SUMMARY—A universal chart for the solution of problems of flow in pipe lines was first presented in the October, 1940, HPAC and is re-published this month as a data sheet on p. 156. Engineers of plants in industries working on national defense—such as aircraft manufacture, for example—showed much interest in this chart, as it can be used for solving problems involving the flow of any liquid, gas or vapor. For gases and vapors, the chart is applicable only as long as the change in pressure is relatively small so that the density may be regarded as substantially constant. . . . In this article a simple modification is presented whereby the universal flow chart may be applied even to the case where large changes in pressure and density occur in the flowing gas or vapor. By using a corrected pressure drop, the universal flow chart may be used even when large changes occur in the pressure and density. . . . One application of the universal flow chart would be where long high pressure steam lines are run to some point only to have the pressure reduced to a low value at the end of the line by means of a pressure reducing valve. In such cases, important economies can be effected in pipe sizes by allowing practically all of the high pressure to be dissipated in the pipe line and installing the regulating valve at the end of a much smaller steam pipe line

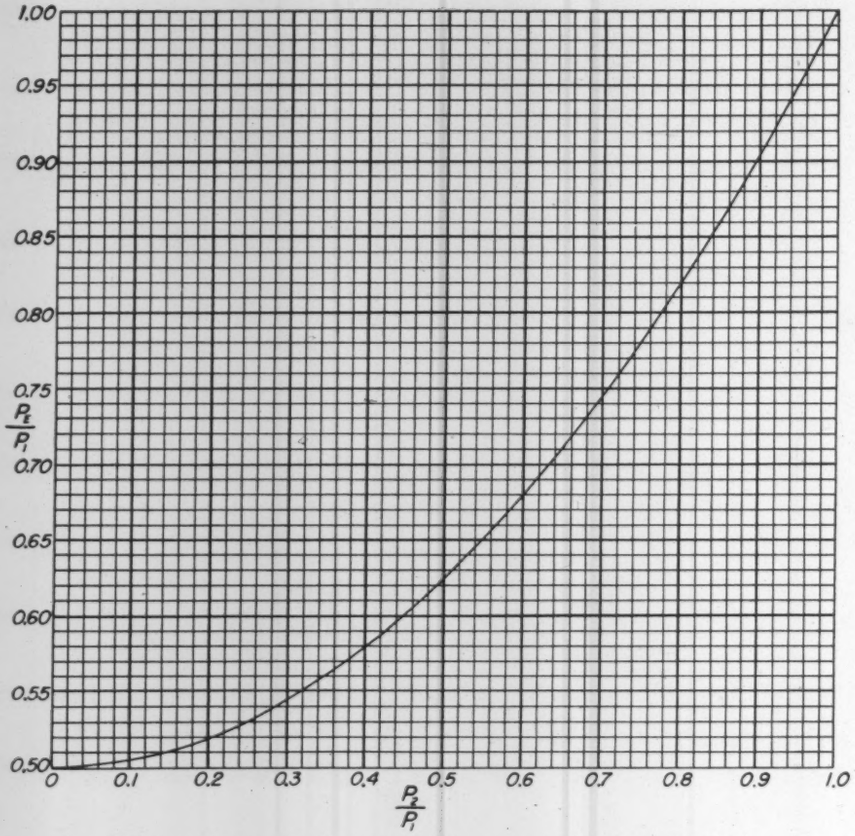


Fig. 1—Curve showing relationship between P_E/P_1 and P_2/P_1

Fundamentally, the universal flow chart was designed to be used only for problems in which the changes in pressure and density are small. However, there is a modified method by which this chart can also be used for problems involving large changes in the pressure and density of the flowing gas.

In order to use this chart under these conditions, a fictitious final pressure must be used instead of the actual final pressure. This fictitious pressure is called the *final equivalent pressure*. The final equivalent pressure is nothing more than the final pressure that would be obtained if the density had remained constant and equal to the initial density throughout the entire length of pipe. The relationship between the final equivalent pressure and the actual final pressure may be obtained from the data in Fig. 1.

The methods described here for solving flow problems involving large changes in pressure and density are based on the assumption that the flow is isothermal—that is, the temperature of the gas or vapor remains constant throughout the pipe.

Symbols Used

D = inside diameter, inches.
d = density of fluid, lb per cu ft.
f = friction factor (see Fig. 5).
L = length of pipe, ft.
N = numerical constant in Equation 2.
P_1 = initial pressure, lb per sq in. absolute.
P_2 = final pressure, lb per sq in. absolute.
P_C = critical pressure, lb per sq in. absolute.
P_E = equivalent pressure, lb per sq in. absolute.
Re = Reynolds' number.
u = viscosity, centipoises.
W = weight of fluid flow, lb per min.

Determining Pressure Drop

Because of the decrease in density, the velocity of a gas will continually increase in the pipe line as the pressure drops. Consequently the pressure drop in this case will be larger than the pressure drop that would occur if the density remained constant and equal to the initial density. The following example illustrates the method of determining the final pressure at the end of a pipe line when a large change in density occurs.

Example 1: Saturated steam at 125 lb per sq in. gage is flowing through a pipe of 3 in. inside diameter at the rate of 200 lb per min. The initial density of the steam (from steam tables) is 0.311 lb per cu ft and its viscosity is 0.018 centipoises. The pipe line is 480 ft long. Find the final pressure of the steam at the end of the pipe line.

Solution: Fig. 2 will be used to illustrate the use of the universal flow chart given on p. 156. Enter the chart at point

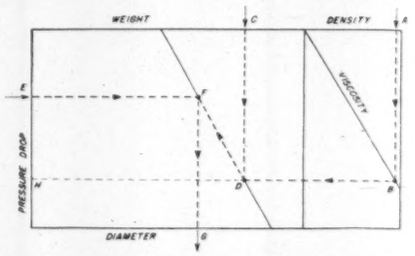


Fig. 2—Skeleton chart showing how universal flow chart is used for determining either the pressure drop or the pipe size

A for a density of 0.311 lb per cu ft. Locate point B where the vertical line through the density of 0.311 lb per cu ft intersects the diagonal viscosity line of 0.018 centipoises. Now enter the chart at C for a flow of 200 lb per min. Extend a vertical line through C until it intersects at D the horizontal line drawn through B. Locate the diagonal directrix line through D. Now enter the chart at G at an internal pipe diameter of 3 in. and extend a vertical line up until it intersects the diagonal directrix line DF at point F. Extend a horizontal line through point F and read at E a pressure drop of 10 lb per sq in. per 100 ft of pipe line.

Inasmuch as the total length of the pipe line is 480 ft, the pressure drop that would be obtained if the density of the steam remained constant would be $P_1 - P_E = (480 \div 100) \times 10 = 48$ lb per sq in. This might be termed the equivalent pressure drop.

It is not the actual pressure drop because with such a large change, there would be a considerable change in the density of the steam. However, by using the curve in Fig. 1, the actual final pressure can be computed as follows:

Initial pressure $= P_1 = 125 + 15 =$ 140 lb per sq in. absolute.

Equivalent final pressure $= P_E = 140 - 48 = 92$ lb per sq in absolute.

$$\frac{P_E}{P_1} = \frac{92}{140} = 0.657$$

Referring to Fig. 1, for $P_E/P_1 = 0.657$, $P_2/P_1 = 0.561$.

Therefore, $P_2 = 140 \times 0.561 = 78.5$ lb per sq in. absolute or 63.5 lb gage, final pressure of the steam.

Determining Pipe Size

Frequently gases or vapors are delivered through a long pipe line only to have their pressure reduced by an automatic pressure reducing valve at the point of delivery. A

saving is possible in pipe size if a large part of the pressure drop is allowed to take place in the pipe line itself.

The following example illustrates a problem in which the pipe size is to be so selected as to take advantage of the fact that only a low pressure is required at the end of the pipe line.

Example 2: Compressed air is to be delivered through a pipe line 275 ft long at the rate of 340 lb per min. The initial pressure of the air is 175 lb per sq in. gage, and the initial temperature is 80 F. The initial density of the air is 0.875 lb per cu ft, and its viscosity is 0.018 centipoises. The final pressure of the air at the end of the pipe line is to be 30 lb per sq in. gage. Find the size of pipe line required.

Solution: First the equivalent final pressure must be found.

$$\frac{P_2}{P_1} = \frac{30 + 15}{175 + 15} = 0.237$$

Referring to Fig. 1, for $P_2/P_1 = 0.237$, $P_E/P_1 = 0.528$.

Therefore, $P_E = 0.528 \times 190 = 100.3$ lb per sq in. absolute.

Total equivalent pressure drop $= P_1 - P_E = 190 - 100.3 = 89.7$ lb per sq in.

Equivalent pressure drop per 100 ft of pipe length $= 100 \times 89.7/275 = 32.6$ lb per sq in.

Using the flow chart on p. 156 in the same manner as illustrated in Example 1, locate the sloping directrix line *DF*, as shown in Fig. 2. Now enter Fig. 2 at *E* for a pressure drop of 32.6 lb per sq in. per 100 ft of pipe length. Extend a horizontal line through *E* until it intersects the previously determined sloping directrix line *DF*. Extend a vertical line down through point *F* and read at point *G* the required pipe size of 2.3 in. inside diameter. This is the size of pipe required to reduce the initial pressure from 175 lb per sq in. gage to a final pressure of 30 lb per sq in. gage.

Rate of Flow

In order to determine the rate of flow through a pipe line with a large pressure drop, the actual final pressure cannot be used. Instead the equivalent final pressure must be used in determining the rate of flow through the pipe line. The following example illustrates the method of determining the flow through a given size line.

Example 3: Saturated ammonia vapor at an initial pressure of 135 lb per sq in. gage is to be delivered through a pipe line 325 ft long. The final pressure at the end of the pipe line is to be 15 lb per sq in. gage. The inside diameter of the pipe is 4 in. The initial density of the ammonia from ammonia tables is 0.502 lb per cu ft and its viscosity is 0.011 centipoises. Find the lb per min of ammonia that can be delivered through this line.

Solution: The equivalent final pressure must first be found.

$$\frac{P_2}{P_1} = \frac{15 + 15}{135 + 15} = 0.20$$

Referring to Fig. 1 for $P_2/P_1 = 0.20$, $P_E/P_1 = 0.52$.

Therefore, $P_E = 0.52 \times 150 = 78$ lb per sq in. absolute.

Equivalent pressure drop $= 150 - 78 = 72$ lb per sq in.

Equivalent pressure drop per 100 ft pipe length $= 100 \times 72/325 = 22$ lb per sq in.

Fig. 3 will be used to illustrate the use of the flow chart on p. 156. Enter Fig. 3

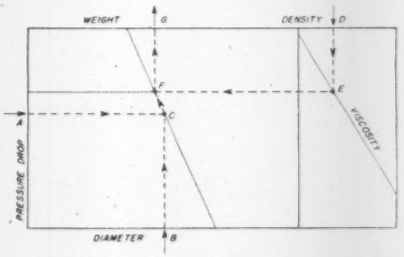


Fig. 3—Skeleton chart showing how universal flow chart is used for determining weight of fluid that will flow through pipe of given size for a given pressure drop

at point *A* for a pressure drop of 22 lb per sq in. per 100 ft. Also enter at *B* for an internal pipe diameter of 4 in. These two lines intersect at point *C*, thus locating the diagonal directrix *CF* through *C*.

Now enter the chart at point *D* at a density of 0.502. Locate point *E* where the vertical line through *D* intersects the diagonal viscosity line of 0.011 centipoises. Extend a horizontal line through *E* until it intersects the diagonal directrix *CF* at point *F*. Draw a vertical line through *F* and read at point *G* a flow of 880 lb per min of ammonia.

Reynolds' Number

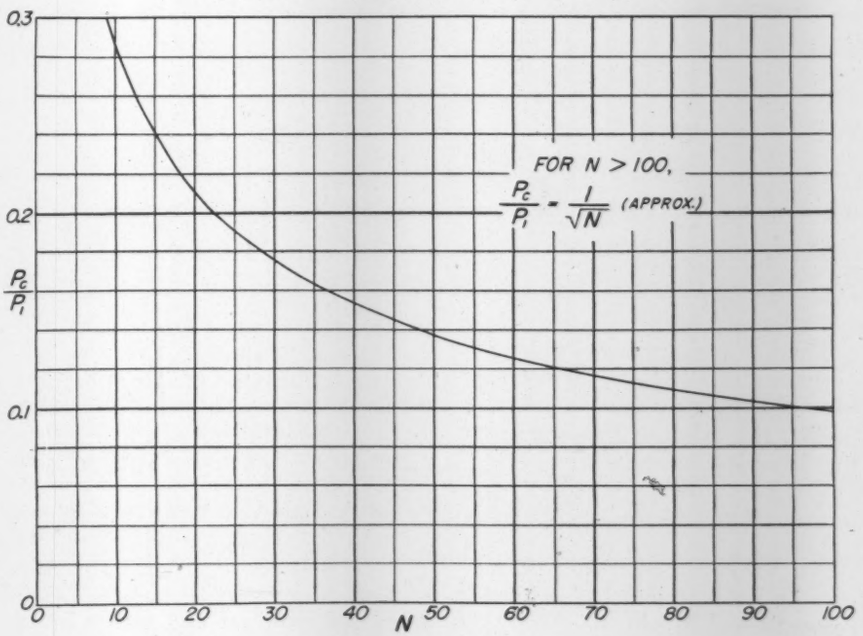
As stated in the article on p. 603 of the October, 1940, HPAC, the universal flow chart may be used only for turbulent flow. The flow will be turbulent if Reynolds' number is greater than approximately 2000. Reynolds' number is computed by means of the following equation:

$$Re = 378.8 \frac{W}{Du} \quad \ldots\ldots\ldots\ldots [1]$$

In problems involving gases and vapors flowing with large drops in pressure, Reynolds' number will nearly always be greater than 2000; that is, the flow will invariably be turbulent. For most gases, Reynolds' number can be less than 2000 only for a very low flow in a large pipe. The computation of Reynolds' number is illustrated in Example 4.

A word as to the viscosity of gases and vapors may also be of help. The change in viscosity with pressure is very small. Theoretically, the viscosity of a gas is independent of its pressure. In actual gases, there is some slight variation in viscosity with pressure which can usually be neglected. For most

Fig. 4—Curve showing relation of P_c/P_1 and N



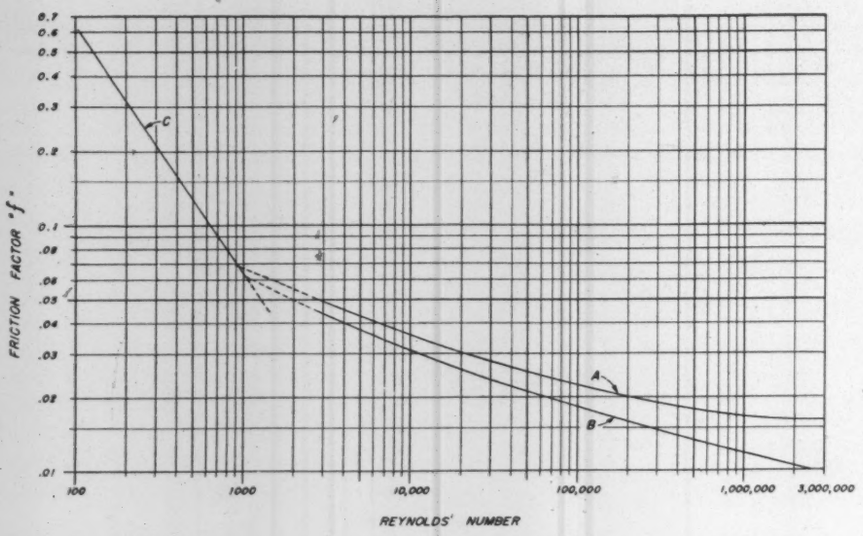


Fig. 5—Curve showing friction factors for various Reynolds' numbers. Curve *A* is for clean commercial steel and cast iron pipe. Curve *B* is for smooth pipe, such as brass, copper, tin, etc. Curve *C* is for streamline flow in any kind of pipe. The friction factor for large size commercial steel and cast iron pipe is lower than the average value given by Curve *A*. The larger the pipe size, the closer the values of the friction factor for commercial pipe will approach the values given by Curve *B*. It is difficult to give an exact pipe size beyond which Curve *A* should not be used, but it is probable that for commercial pipe above approximately 8 in. in size the friction factor is given more accurately by Curve *B*

gases and vapors, the viscosity varies appreciably only with the temperature.

The viscosity of steam, air and ammonia was given in Fig. 2 on p. 628 of the October, 1937, HPAC.

Critical Pressures and Maximum Flow

If a flowing gas is expanding in a pipe line, the flow may reach some maximum value. No matter how much the pressure at the outlet of the pipe is decreased, the flow in the pipe line will not increase beyond this maximum. [For a fuller discussion of this point, see p. 691, November, 1937, HPAC.]

The flow in the pipe line will take place exactly as though some higher pressure than the actual pressure existed at the outlet of the pipe. This higher pressure is called the *critical pressure* because it represents the final pressure which will cause the maximum flow through the pipe. Regardless of how much the actual final pressure is lower than the critical pressure, the flow through the pipe will not increase beyond the flow that would be obtained if the actual final pressure were equal to the critical pressure.

The critical pressure for any given set of conditions can be determined from Fig. 4 after first finding the value of N by means of the following equation.

$$N = 12 f \frac{L}{D} \quad \text{.....[2]}$$

The value of the friction factor, f, may be read from Fig. 5 after first computing the value of Reynolds' number, Re, by means of Equation 1.

When low final pressures are given in a problem, the critical pressure should always be determined. If the critical pressure is lower than the given final pressure, the critical pressure may be ignored as it will not affect the solution. However, if the critical pressure is higher than the given final pressure, the flow obtained with the given final pressure cannot be obtained. Instead, the problem must be solved by using the critical pressure instead of the actual given final pressure.

The following example illustrates the method of determining and using the critical pressure.

Example 4: Take the conditions of Example 1 and determine whether the flow of 200 lb per min of steam given there can be obtained.

Solution: Using the data of Example 1 and Equation 1,

$$Re = 378.8 \times \frac{200}{3 \times 0.018} = 1{,}400{,}000$$

Referring to Curve A of Fig. 5 for $Re = 1{,}400{,}000$, $f = 0.017$.

Using Equation 2, $N = 12 \times 0.017 \times (480 \div 3) = 32.6$.

Referring to Fig. 4 for $N = 32.6$, $P_c/P_1 = 0.17$.

Therefore, $P_c = 0.17 \times 140 = 23.8$ lb per sq in. absolute.

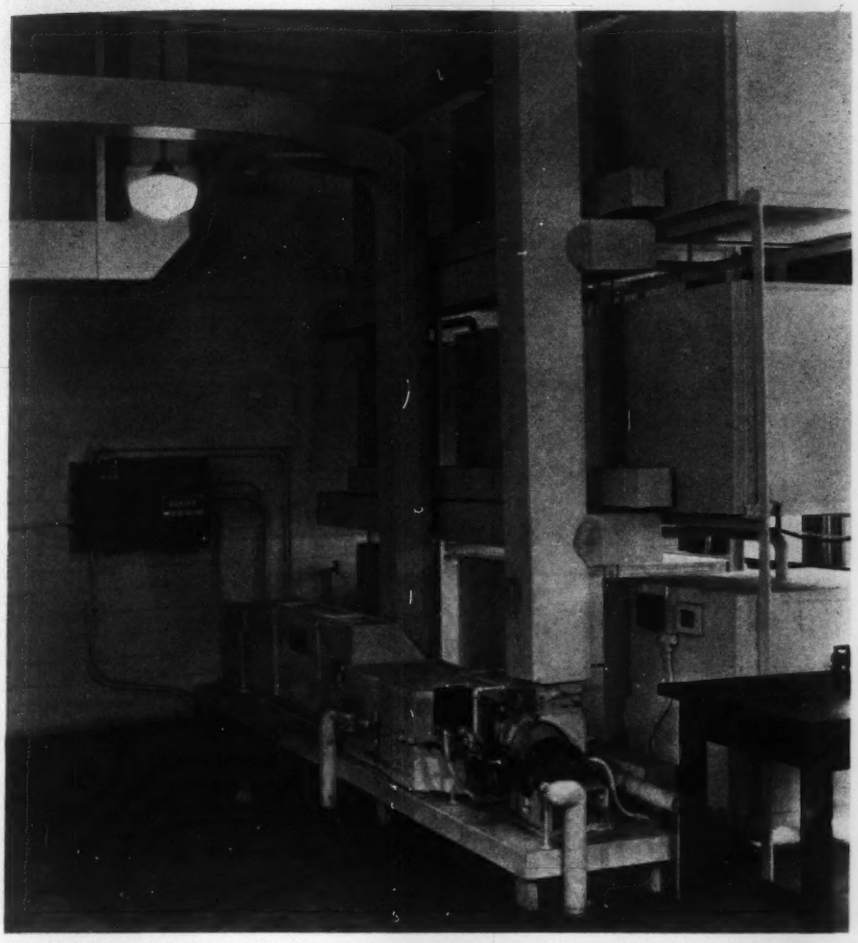
From Example 1, the actual final pressure is 78.5 lb absolute, which is higher than the critical pressure of 23.8 lb per sq in. absolute. Therefore, the conditions of Example 1 are satisfactory and the flow given there will be obtained.

If, in Example 4, the critical pressure were higher than the actual final pressure, then the flow stated in the problem could not be obtained. Instead it would be necessary to solve the problem again using the critical pressure instead of the actual final pressure. In this case the critical pressure would be used to find the equivalent final pressure, and the problem would then be solved in exactly the same manner as was done in the case of Example 1.

The maximum flow through a given pipe line can be determined only by trial and error. Various final pressures should be assumed and the flow computed as in Example 3. At the same time the critical pressure should be determined for each value of the computed flow in the manner illustrated by Example 4. The value of the flow for which the critical pressure and the actual final pressure are the same is the maximum flow through the pipe line.

Graph paper is of value in determining the maximum possible flow. For this purpose the computed flow is plotted against each of the various assumed actual final pressures. On the same sheet of graph paper also plot the computed critical pressure against the flow. The same scale should be used for both the critical pressure and the final pressure. The maximum flow can then be read at the point where the two curves intersect.

"We would like to obtain 30 copies of the article "Piping Flow Problems Made Easy" from the October HPAC for distribution to those taking our training courses in national defense," writes an aircraft company as we go to press.



Almost Fits the Pocket

....this diminutive central station air conditioning system at the Kettering Laboratory... By Henry W. Moore*

SUMMARY — This diminutive central station air conditioning system supplies a total of 207 cfm, has a direct expansion coil 10 in. by 10⅞ in. in face area supplied by a 2 hp compressor, copper duct work of 2 in. diameter. Air is filtered first by a washable steel filter and then by an electrical precipitator. It serves nine animal boxes—the backs of which are shown in the photograph—used at the Kettering Laboratory of Applied Physiology at the University of Cincinnati in studies on industrial health. (The air duct directly behind the electric light fixture is not a part of this system)

THE Kettering Laboratory of Applied Physiology in the College of Medicine of the University of Cincinnati installed last year what is perhaps one of the most unusual air conditioning systems in the country. This installation supplies conditioned air to nine animal boxes which house rabbits and monkeys for experimental work. This system is unique—particularly due to its minute size. It is a "watch charm" affair, yet it has some of the complexities and refinements of a large, modern public building plant. The total air supplied by the system is only 207 cfm.

This research organization is engaged in the study of industrial health and diseases of occupation. It was in this laboratory that the early studies on the toxicity of the commonly used refrigerant dichlorodifluoromethane ("Freon") were made.

The occupants of the nine air conditioned animal boxes are subjected to various experimental atmospheres to simulate different industrial working conditions. The physiological effects upon the rabbits or monkeys are carefully noted and the effects of such atmospheres on human beings under working conditions can be estimated. The purpose of conditioning these boxes is to see that the air which normally enters them is perfectly pure and of the desired temperature and humidity, so that when the materials and dusts under study are added to the air supplied to the boxes, the composition of the mixture will be accurately known. Each of the boxes is totally enclosed and has a 24 in. square glass door. If the air is not conditioned, the humidity given off by the animals soon fogs the glass door, makes it impossible to observe them and, of course, affects them physiologically. The boxes are each 3 ft 6 in. long by 2 ft 6 in. wide by 2 ft 6 in. high inside. They are constructed of 1 in. plywood insulated externally with 1½ in. of board insulation. The air conditioning equipment was designed with sufficient capacity to condition three additional similar boxes or one man-sized box at a later date should this be desired.

Design Conditions

The system was designed to produce inside conditions of 75 F dry bulb, plus or minus 2 F, with a maximum relative humidity of 50 per cent, plus or minus 5 per cent, when the outside temperature is 95 F dry bulb and 78 F wet bulb or below. The dehumidifying capacity was also checked for humid, warm days when the outside condition is 85 F dry bulb and 78 F wet bulb.

In the heat load, a maximum of three average sized rabbits, each weighing approximately 7 lb, was considered. Some difficulty was encountered at first in determining the amount of heat given off by each rabbit and what per cent of that heat was sensible and latent. Members of the laboratory staff assisted in this connection, and the load was based on the liberation by each rabbit of

*Manager, Air Conditioning Engrg. Dept., Bimel Co.

15 Btu per hr sensible heat and 23 Btu per hr latent. All the conditioned air introduced into the boxes is taken from the outside corridor of the building. In other words, no air is recirculated, and the air is drawn from the large corridor rather than directly from the outside because that air is sufficiently "fresh" and yet never reaches the extreme conditions of the outdoors.

23 Cfm Per "Room"

One 25 watt electric light was figured in the heat load for each box. The total supply air to be provided per box was only 23 cfm, or a total of 207 cfm for the nine boxes. This provides a complete air change in each box approximately once each minute.

The air is first filtered by a permanent, washable steel filter to remove the relatively large dirt and dust particles, and then is passed through an electric precipitator type air filter. The air leaves the precipitator and enters the fin type, "Freon" cooling and dehumidifying coil, which is 10 in. by 10⅞ in. in face area and 10 rows of tubes deep.

A 2 hp reciprocating compressor supplies the cooling coil. This compressor, with water cooled condenser, was originally on the same floor as the other equipment, but it was later moved to a platform on the lower floor to eliminate vibration in the laboratory where the animal boxes are situated. After leaving the cooling coil, the air travels through a steam reheat coil. The air then passes through the small, directly connected centrifugal blower and thence to each box.

2 In. Copper Ducts

The air enters the box through a small 2 in. diameter duct connected to the extremely small air diffuser ceiling outlet. One interesting problem was to protect the ceiling outlets from possible damage caused by the monkeys swinging on them. This was handled by merely placing a cross-wire screen over each outlet.

The exhaust air is removed from the lower part of the box, being drawn from beneath a platform provided for the animals to walk on. This exhaust air is discharged by means of another blower similar to the supply fan, discharging the air into a common flue. A manually operated blast gate type of damper was necessary, to be closed when the exhaust fan is not in operation. If this damper is not closed, the acid fumes from the chemical hoods on the floors below will enter the system and soon seriously damage it. There is a special lever for operating this blast gate from the floor.

All duct work was made of 16 oz per sq ft copper to protect it from the gases that are supplied to the air to simulate the various industrial conditions. The conditioner housing was made of galvanized iron, since the experimental gases will never reach that section of the system.

Master Control Box

The temperature and humidity control system was designed on the basis of using one animal box as a control box. Similar, uniform conditions will be maintained in all boxes only if they are loaded equally with animals and lights. This method of control, while not theoretically perfect, was decided upon to eliminate the complexities and extra expense of a separate control for each box. Incidentally, it has been found quite satisfactory in actual use.

The air flow to each cage must be accurately determined for experimental purposes and an arrangement was made to do this by means of a venturi nozzle measuring device, similar to the way in which water flow is measured. The vapor or gas is admitted just before the air enters each box. This permits various experiments to be conducted simultaneously, using different industrial air conditions in different boxes.

This system was installed in February and March of 1940 and has been in actual operation for about eight months. Workers in the laboratory have stated that they are well pleased with the results they are getting.

Reducing Atmospheric Pollution

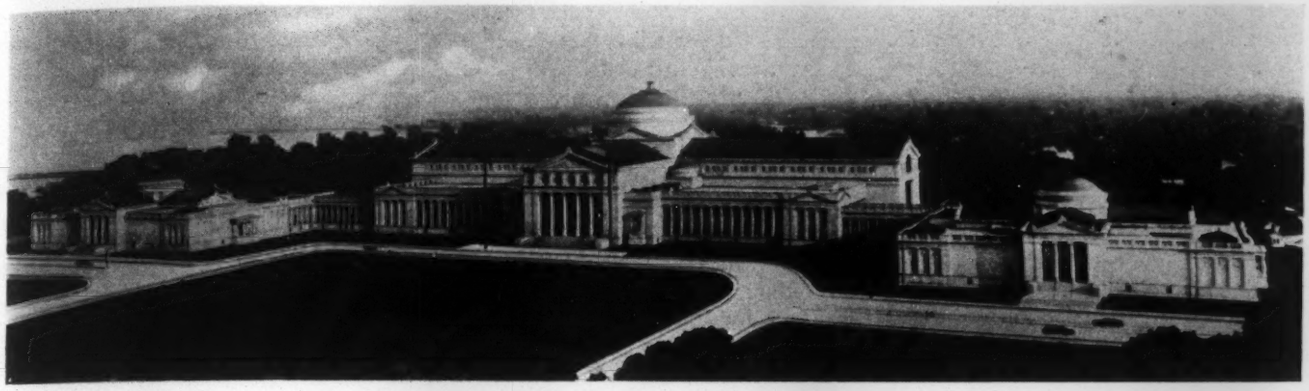
Dr. R. V. Kleinschmidt and A. W. Anthony, Jr., consulting engineer and president, respectively, of the Pease-Anthony Equipment Co., described improved "scrubbing" methods for the reduction of atmospheric pollution due to industrial waste gases, fly ash and dust at the 61st annual meeting of the American Society of Mechanical Engineers.

It was pointed out that though it is only four years since the first full plant cyclonic spray scrubber was installed, developments have been so rapid that early installations must now be regarded as obsolete despite their continued useful operation.

The speakers indicated possible uses for the waste materials removed from flue gases, pointing out that some use is already made of fly ash for admixture in cements and in the building block industry. Possible benefits were also indicated in the recovery and use of sulphur dioxide (SO_2) now allowed to escape to the atmosphere. The gas, it was said, might not only be sold but its removal would also eliminate corrosion problems in induced draft fan wheels and remove present arguments as to its possible harmful effects in the atmosphere.

"When flue gases are thoroughly scrubbed, the SO_2 present is a problem from either the standpoint of corrosion or of disposal of the recoverable byproduct. However, if the gases are dry cleaned, there is no problem at least to the boiler plant operator, since the SO_2 is turned loose to the prevailing winds. Papers have been published to prove that SO_2 harms neither plants nor human beings, but nothing has yet appeared showing beneficial effects on life, or on steel, concrete, paint, etc. In short, SO_2 is on the defensive, and is generally considered as a nuisance.

"If public interest is justified in requiring substantial elimination of cinders and fly ash from power plant stacks, there is even more justification for requiring the elimination of SO_2, because probably the complete job can be done ultimately at small increase in annual cost of effective solids removal. If, however, SO_2 recovery is expected to show a profit after meeting annual costs not only on its own operations but also on those for solids removal as well, then the outlook for general acceptance is not favorable."



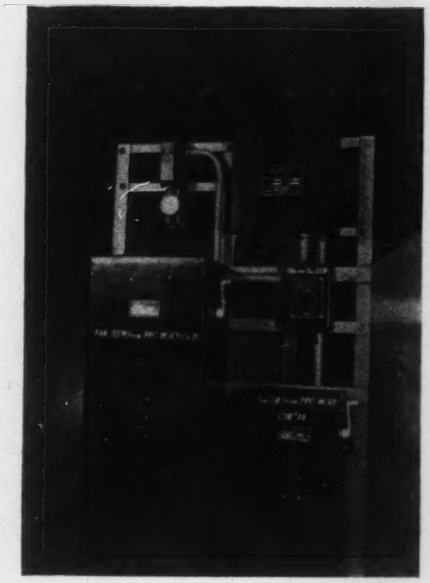
The equipment and piping identification scheme used at the Museum of Science and Industry, Chicago, can be applied to advantage by others

Identifying Your Mechanical Equipment Simplifies Operation and Maintenance

AS an aid to operation and maintenance of the heating, ventilating, air conditioning, piping and other equipment at the Museum of Science and Industry, Chicago, a careful scheme of marking and identifying the apparatus is used. In this way a great deal of time and trouble is saved when apparatus needs repair or maintenance work, and the job of keeping the vast amount of equipment in good order is simplified. The idea can be applied to advantage in many plants and buildings.

According to Lester Seelig, Chief Engineer of the museum, the scheme was initially used for the operating exhibits at the museum and worked out so well that it is now being carried over into the mechanical and electrical equipment of the building itself. There are many exhibits requiring various steam or electrical connections, and if one of them gets out of order, the staff makes every effort to locate the trouble immediately so that visitors will not be disappointed. By carefully identifying the various switches, fuses, valves, etc., it has been possible to do this. The same idea is equally if not more important with the equipment serving the building itself.

With the system adopted, the starter cabinet for the motor driving an oil pump in the boiler room is, for example, identified as follows: "Oil Pump No. 2. From PPC-FC4 Cir. No. 16." This legend indicates which pump motor is controlled by the cabinet and also shows the source of power to the cabinet. In this case, PPC-FC4 indicates primary power cabinet in fan room No. 4, central pavilion. Cir. No. 16 means electrical circuit No. 16. In this way, the maintenance and operating men have complete information for checking the circuit to locate any trouble.



Controls for fans

SUMMARY—Many operating and maintenance men can apply the identification scheme used at the Museum of Science and Industry, Chicago, to advantage. The various items of mechanical equipment are marked to show what parts of the building or what other equipment they serve. Source of power is also indicated, so if there is any electrical trouble, the circuit can easily be traced. . . . There are also circuit diagrams posted right with the apparatus to facilitate location of any difficulty. . . . The idea was first used for the operating exhibits on display at the museum, and worked out so well that it is being adapted to the building mechanical equipment too

On the starter box for one of the ventilating fans, the legend might read "Fan S-5W Lecture Hall. From PPC-W301 Cir. No. 6." This indicates that the fan driven by the motor controlled by this starter box is supply fan No. 3 serving the west pavilion (lecture hall) and that the power to it comes from the primary power cabinet in the west pavilion, No. 301, third floor, electrical circuit No. 6.

The other equipment is labeled in similar manner to the starter cabinets. For instance, the various fans are marked with the rooms they serve, and the ducts, including the various branches, are also marked in this way. Thus, if there is a shift of occupancy from one room to another, or some trouble with the ventilation of any room, the operating men know exactly what ducts and fans supply these rooms. There is also a central control board in the

boiler room for starting, stopping or changing speed of any one of the fans.

In addition to marking the equipment itself, diagrams of the various systems and circuits are posted right with the apparatus for use by the operating men and these are also a great help. They show the various control or electrical circuits and permit quick tracing of the circuit and location of any switches, relays and other apparatus in the circuit. The diagrams posted with the equipment are black line prints, and the master tracings are kept in the drafting department. When any changes are made they are immediately indicated on the prints, and then as the draftsmen have time, the original drawings are revised.

Piping Identified

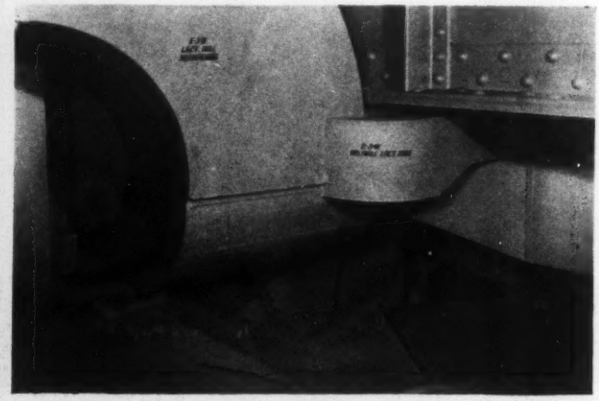
The various piping systems throughout the building are identified by color bands painted on them. All water piping, for instance, is identified with an 8 in. band of blue, and if it is for the fire protection system, a narrower band of red is shown in the center of the blue band. Water piping for other services also has the 8 in. blue band but with a different colored narrower band for identifying the use. Steam, gas, sewage, and electrical lines are also identified by other color combinations.

The Museum of Science and Industry is a monumental type of building, situated right on the shore of Lake Michigan in Jackson

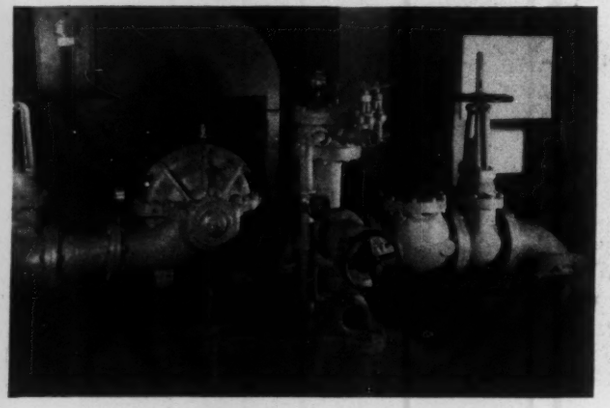
VIEWS OF EQUIPMENT AT MUSEUM, SHOWING THE MARKING SCHEME USED

[All photos of equipment by H. F. Balmer]

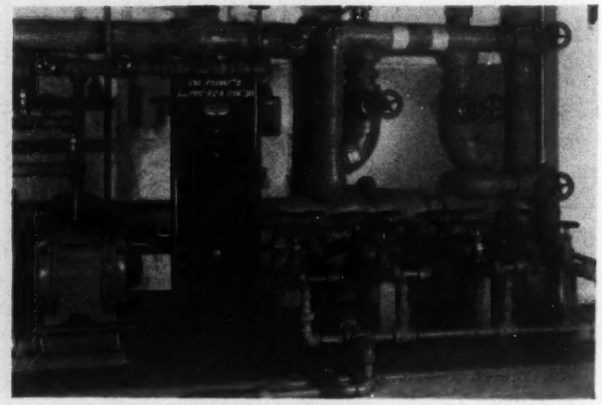
Hot water heater, showing the marking of the piping



Marking of duct branches

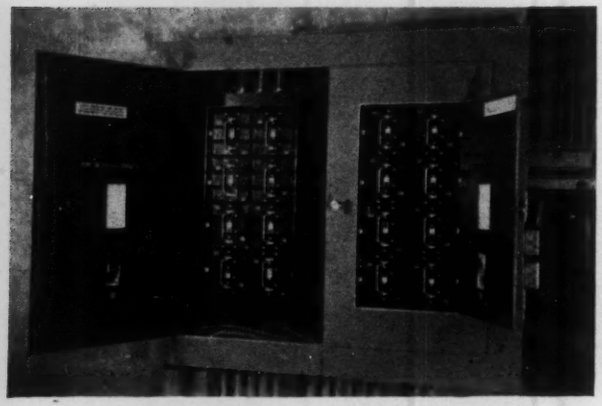


Fire pump and control

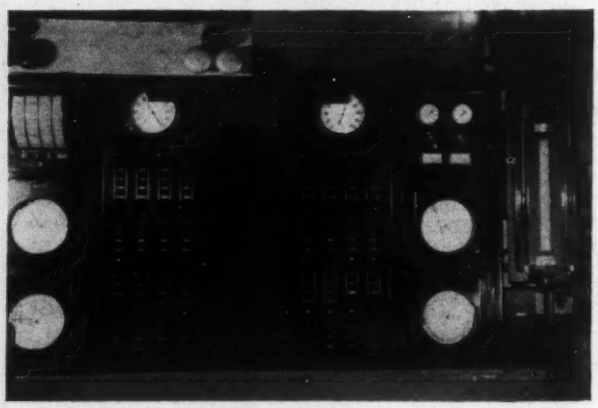


Fuel oil pump and control

Power supply cabinet



Boiler room and fan control board



Park. Originally it was the fine arts building at the Chicago Columbian Exposition. Many unusual and unique operating exhibits are on display there. One of the most popular is the full-size model of a coal mine, and one of the newest is an operating model of an extensive railway system which was given to the museum by the Atchison, Topeka and Santa Fe Railway. There is also a large corliss engine in operation and in winter the exhaust steam from it is used for building heating, and in summer for heating service water.

Piping Identification Color Code Used at Museum

WATER: Wide blue band. Narrow band in center: High pressure, black; fire system, red; boiler feed, brown; city pressure, none; drinking (cooled), white; hot, yellow; hydraulic supply, green; hydraulic return, gray.

STEAM: Wide white band. Narrow band in center: High pressure, red; low pressure, none; exhaust, green; vacuum return (cond.), black; vacuum return (water), blue; blow-off line, yellow.

AIR: Wide yellow band. Narrow band in center: Compressed, none; vacuum, black.

WASTE: Wide brown band. Narrow band in center: Sewage, red; storm water, white; drainage, none.

ELECTRIC LINES: Wide black band. Narrow band in center: Light and power, none; telephone, cream.

GAS AND OIL: Wide red band. Narrow band in center: Fuel oil, black; city gas, none; "Freon", white.

Note—Wide band is 8 in. long and narrow band in center is 3 in. long. Bands to be placed on discharge side of all valves and fittings.

PRESSURE STORAGE VESSELS

Merl D. Creech, engineer for Black, Sivalls & Bryson, Inc., described research undertaken to eliminate the danger of loss of life and property damage due to explosions of industrial pressure storage vessels at the annual meeting of the American Society of Mechanical Engineers. He described experiments making use of rupture disks to relieve harmlessly the explosion pressures. He said in part:

"In many industrial applications a pressure vessel is used for the storage of an explosive mixture of compressed air and some combustible vapor. Each of these installations represents a hazard to life and property. A common example is air receivers. Although compressed air is not in itself explosive, the introduction of oil into the receiver either from a defective compressor or by faulty operation does create a condition responsible for explosions. Even though these vessels are always provided with relief valves to safeguard them from overpressure, they are not protected from the very rapid pressure rise during a combustion explosion of their contents.

"The experimental data are merely a first step toward the solution of this problem. This matter is quite complicated and much must yet be learned about combustion explosions in general before the problem can be called solved. Many of the variables which might affect the results were either disregarded or only crudely or partially controlled. However, the results thus far obtained do indicate that by using a higher factor of safety in designing the vessel together with a rupture disk of suitable size, every vessel containing an explosive combustible mixture can be protected. For many of the less violently explosive mixtures, a rupture disk alone will give absolute protection from a destructive explosion."

INCREASES PRODUCTION

The Square D Co. recently transferred its Milwaukee offices and all production of the industrial controller division to a new 125,000 sq ft plant, where production capacity has been increased 50 per cent.

Thermostatically controlled ceiling projection type unit heaters at 17 locations throughout the plant have a combined heating capacity of 5,638,000 Btu and a blower capacity of 82,300 cfm. They are served by two completely automatic oil burning boilers with an SHBI steam rating of 18,220 sq ft each. A separate oil fired boiler for process steam, rated at about 35 hp, meets the year 'round requirements for hot water and process steam. Wiring for all electrical controls serving the automatic boiler equipment is carried in 4 in. square duct, which provides ready access to all of the motors and control units that have been compactly nested behind the boilers. Oil for boiler operation is stored in two 10,000 gal tanks underground, which are connected to the building through a 30 ft concrete pipe tunnel, 7 ft wide.

Two air conditioning units serving the office section are situated alongside the wall which separates plant and office areas. They use water pumped from a deep well at 50 deg for cooling. After it passes through the sprays in the air conditioning chamber, this water is pumped to a standing pond on the office roof to reduce the cooling load in summer. It overflows from the roof to pipes connecting with the lawn sprinkler system and is used for this purpose or wasted to sewers.

FUEL OIL SYSTEM SUPPLEMENTS GAS

An extensive program is being completed at the plants of the Timken Roller Bearing Co. to provide for every possible contingency that might arise to cause interruptions in production of the large amount of defense work that is flowing through the company's plants, according to a recent announcement.

A heavy fuel oil system is being installed to assure the continued operation of equipment being used on defense work, in the case of possible failure of the natural gas supply which has been used heretofore.

This fuel oil system consists of a large "tank farm" comprising a central storage to accommodate 1,250,000 gal of heavy fuel oil, sufficient for a month's capacity operation. As an additional precaution, provision is being made so that the fuel oil can be pumped direct from five cars at one time into feeder lines leading to two distributing tanks of 100,000 gal capacity each, located in the central part of the plant. This "tank farm" is hooked up to the company's open hearth furnaces, billet heating furnaces, and soaking pits of the Canton plant. A separate unit is being installed at the Gambrinus plant.

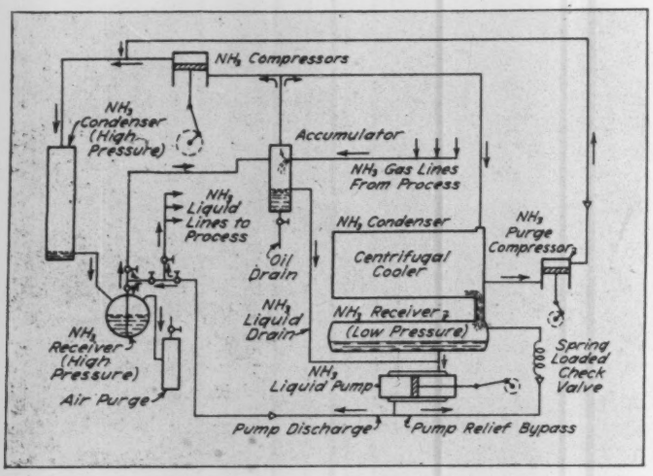
Improving the Plant Heat Balance

W. S. Bodinus* Explains How Centrifugal and Reciprocating Refrigeration Machines Can Be Installed to Work Together

WHERE exhaust or high pressure steam is available the centrifugal refrigeration compressor driven by a steam turbine can be used to improve the heat balance. The refrigerating unit simply becomes an element in the complete heat balance of the plant.

The turbine driven centrifugal refrigeration machine can be installed so as to operate either alone or in parallel with existing reciprocating compressors in certain industrial process applications. Referring to the sketch, the suction lines return from the process to the accumulator, where slugs of liquid refrigerant and oil are deposited and drained, the liquid ammonia being drained directly to the suction of an ammonia liquid pump and the oil to a suitable pail or barrel. A separation of the oil and liquid ammonia takes place in the accumulator because of the difference in gravity; liquid level indicators at the side of the drum tell the operator when to drain oil, and draining of the liquid ammonia is entirely automatic. It is interesting to note that, in one installation, after the accumulator was installed many barrels of oil were drained from the system; this oil had previously reduced efficiency of the evaporators.

From the accumulator the low pressure gas can go to the suction of the ammonia compressor or to the cooler of the centrifugal machine. If the load is heavy and



Method of cross-connecting centrifugal and reciprocating compressors to operate in conjunction for improving heat balance

both the centrifugal and reciprocating compressors are required, the gas taken by the ammonia compressor is compressed and liquefied at the high pressure (say 180 lb per sq in.) in the high pressure ammonia condenser and then is drained to the high pressure receiver. The remaining gas goes to the cooler of the centrifugal machine (which is also the low pressure ammonia condenser), and here it is condensed at low pressure and temperature (say 15 F) and drains to the low pressure receiver. The ammonia liquid pump takes it from the receiver and pumps it into the supply line against the high pressure established by the ammonia compressors. The ammonia vapor is condensed in the cooler tubes because the temperature of the centrifugal machine's refrigerant in the shell (and consequently on the outside of the tubes) is maintained a few degrees below the temperature at which the ammonia will condense.

A check valve in the ammonia liquid pump line prevents return of liquid and loss of pressure if the pump is shut down. The liquid pump is usually of the slow speed reciprocating type and operates with a very low submergence; that is, a low liquid head on the inlet side. Since the liquid ammonia is at the saturation temperature, some flashing into gas occurs at the pump, and the pump is therefore selected over-capacity to allow for this loss. For instance, if 50 lb per min of NH_3 is to be circulated then a 100 lb per min pump is used. When the ammonia compressors are shut down and the centrifugal machine is operating alone, the ammonia liquid pump must not only supply the liquid to the lines but it should also maintain a constant pressure. As the pump is over-capacity, a spring loaded check bypass valve is installed to return the excess to the low pressure receiver.

To obtain the best heat transfer conditions in the low pressure ammonia condenser, six passes are usually provided. By graduating the amount of surface in these passes—a large amount in the first pass and a small amount in the last pass—the velocity is high, and thus carries the liquid ammonia to the drains at the end of each pass and also prevents the accumulation of any noncondensable air which may be in the system.

It is inevitable that air will get into the system due to opening up lines for changes or repair and that this air will be brought to the low pressure ammonia condenser and will impair its efficiency if allowed to remain. To get rid of it, a small one cylinder ammonia compressor is connected, with its suction, to the last pass, where the air will accumulate. This compressor pumps the air into the high pressure system, which is provided with an automatic air purge for venting to the atmosphere.

When the centrifugal and the ammonia compressors are operating together, the supply of liquid ammonia going to the process (being a mixture of high temperature and low temperature) would vary in final temperature and affect the setting of hand expansion valves. To correct this, a line is run from the high temperature receiver to the accumulator and all of the liquid is supplied to the process by the pump at the uniform low temperature. This is obviously an advantage since the cold liquid NH_3 supply eliminates the generation of flash gas at the expansion valves and increases the efficiency of the evaporators or cooling coils by 10 to 20 per cent.

*Carrier Corp.

Flow in Piping

William Goodman* Explains Use of Universal Flow Chart

SUMMARY—Because of their convenience, charts are widely used for sizing piping systems. The universal flow chart reproduced on the next page eliminates the need for a separate chart for each fluid as it is based on Reynolds' numbers and is universal in scope as long as the flow is turbulent and not streamline. This may be determined by a simple equation, and except for oil, flow is turbulent for most of the cases encountered in commercial engineering work . . . The chart can be used not only to size a pipe for a given rate of flow and pressure drop, but also to determine the rate of flow for a given pipe size and pressure drop, or the pressure drop for a given pipe size and rate of flow . . . A particularly helpful use of the chart is in quickly determining the pressure drop for several different pipe sizes

THE universal flow chart on the next page can be used for solving problems involving the flow of any fluid through pipe lines, regardless of whether that fluid is in the liquid or gaseous form.

The only limitation on the use of the universal flow chart is that the fluid must be in turbulent motion. The fluid will be in turbulent motion if Reynolds' number is greater than approximately 2000. For any particular problem, the value of Reynolds' number can be determined by means of the following equation:

$$Re = 378.8 \frac{W}{Du} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where Re = Reynolds' number;
W = weight of fluid flowing, lb per min;
D = inside diameter of pipe, in.;
u = viscosity of fluid, centipoises.

Finding Pressure Drop or Pipe Size

To find either the pressure drop or the pipe size, the following three quantities must be known: (1) Weight of fluid flowing through the pipe. (2) Density of fluid. (3) Viscosity of fluid.

These three quantities are used to locate a single diagonal directrix line along which all the various corresponding pressure drops and pipe sizes may be read for the given flow, density, and viscosity. Thus, referring to Fig. A, the diagonal directrix line F-D is located as follows: Enter the chart at A for the given density. Locate B where the vertical line through A intersects the diagonal line for the given viscosity. Now enter the chart at C for the given flow. Point D is located where the vertical line through C and the horizontal line through B intersect.

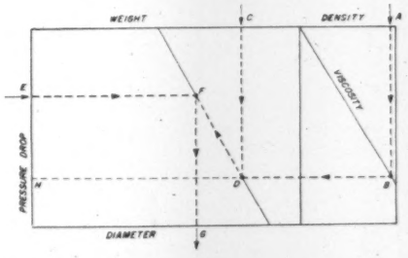


Fig. A—Skeleton chart showing how universal flow chart is used for determining either the pressure drop or the pipe size

The diagonal directrix line F-D through D can now be used to determine the pressure drop for any given pipe size, or vice versa. For example, for a certain problem, the following combinations of pipe sizes and pressure drops were read along a single directrix line located as described above.

Pipe Size In.	Pressure Drop Lb per Sq In. per 100 Ft
2	7.5
3	1.1
4	0.27
5	0.09
6	0.037

Finding Rate of Flow Through Pipe Line

To find the rate of flow through a pipe line, the following quantities must be known: (1) Pipe size. (2) Pressure drop per 100 ft of pipe length. (3) Density. (4) Viscosity.

These quantities are used in the manner illustrated in Fig. B to determine the weight of fluid that can flow through a pipe line. Referring to Fig. B, enter the chart at A for the given pressure drop per 100 ft of pipe length. Also enter at B for the given pipe size. Point C is located where the horizontal line through A and the vertical line through B intersect. The diagonal directrix line C-F through C is thus located. Next, locate point D for the given density. Point E is located where the vertical line through D intersects the diagonal line for the given viscosity. Extend a horizontal line through E until it intersects at F the diagonal directrix C-F. The rate of flow through the pipe is read at point G, which is located on the vertical line through F.

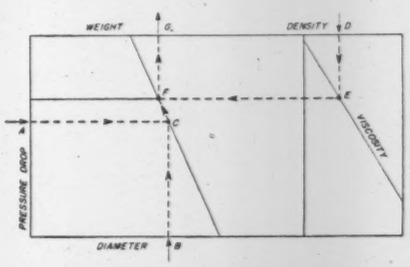


Fig. B—Skeleton chart showing how universal flow chart is used for determining weight of fluid that will flow through pipe of a given size for a given pressure drop

Examples illustrating the use of the universal flow chart will be found in the article on p. 603 of the October, 1940, HPAC and in the article on p. 145 this month.

*Consulting Engineer, The Trane Co. Member of HPAC's Board of Consulting and Contributing Editors.

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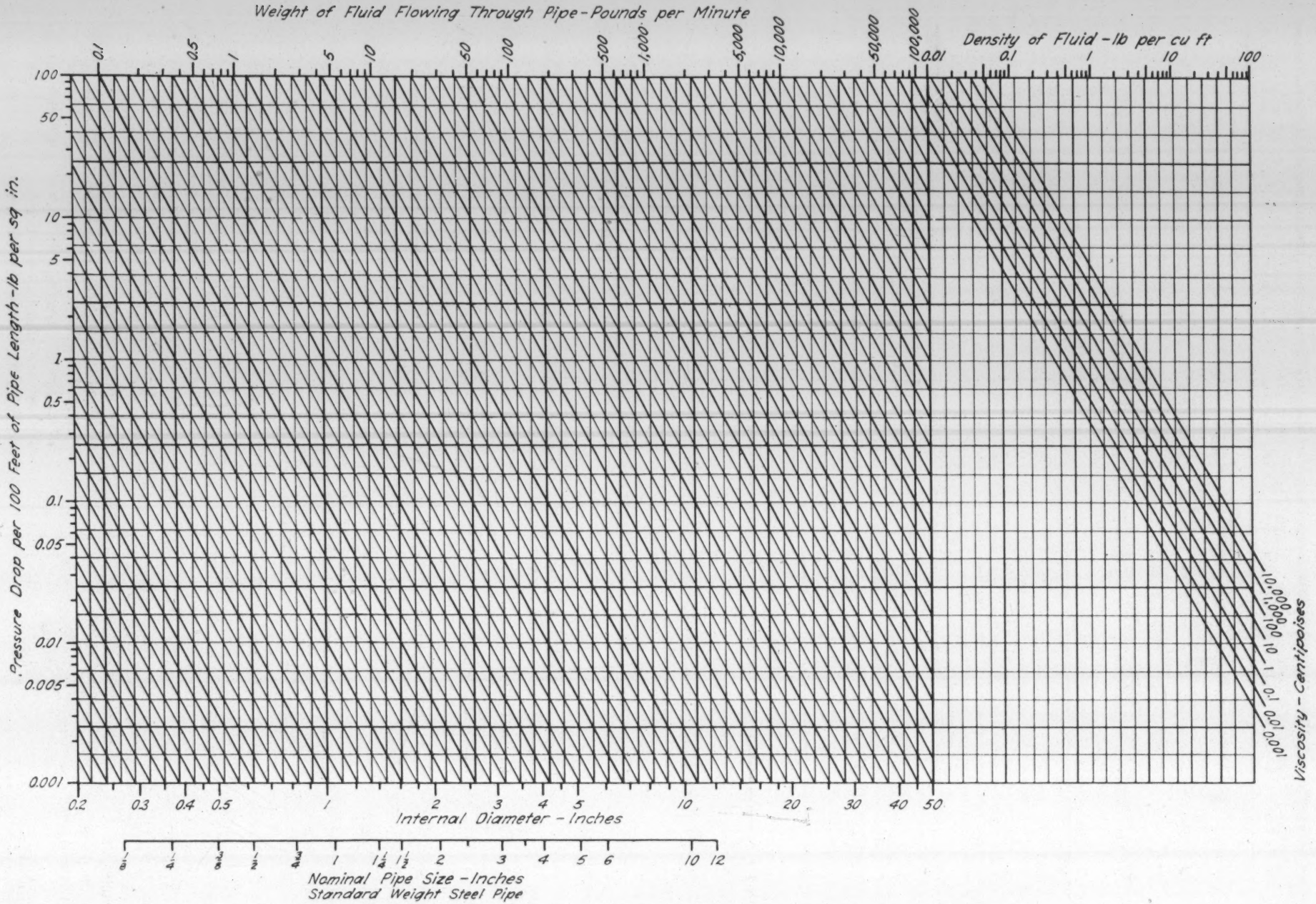


Universal chart for fluids in turbulent flow for determining pressure drop, pipe size, or rate of flow

[For clean commercial steel or cast iron pipe. For clean copper pipe the pressure drop will be lower than that obtained from this chart. Consequently, the chart may be safely used for copper pipe. See explanation of use on preceding page.]

Why Do INSURANCE COMPANIES Air Condition?

H. L. Schwenker, Vice-president and Actuary of Lincoln Liberty Life Insurance Co., Explains Many Advantages

IN SEPTEMBER, 1936, the Lincoln Liberty Life Insurance Co., Lincoln, Neb., completed the remodeling of its home office building. Included in the modernization was an air conditioning system, complete except for the street floor.

When we first gave consideration to installing an air conditioning plant we were measuring its value largely in terms of comfort and relief from the summer heat with the resultant effect on efficiency of work. This phase has proved to be one of the big benefits—but we question its being the greatest. To our surprise we have concluded after four years' experience that on the basis of a pure business analysis there are other important factors which together most certainly outweigh the benefit of summer cooling, and probably some of them do individually.

ABOVE

Three 25 hp compressor units in the basement supply floor type air conditioner units on each floor of Lincoln Liberty Life's modernized home office building. Outside air is introduced by a 10,000 cfm fan situated in a penthouse

Health Improved

Drafts—For instance, one of the very troublesome problems during the cooler months was that of conforming to both so-called cold and warm blooded individuals. One prefers high temperature even at the cost of stuffy atmosphere; the other must have his window open even though his neighbor complains about the draft. This situation is not humorous—it is very real and serious when it must be met, but we are now free from that annoyance.

Hay Fever—Some very good human interest experiences have been enjoyed by us during the past four years. We say "enjoyed" because it is a definite pleasure to know that you have been instrumental in bringing comfort to a suffering individual. We refer particularly to that large and apparently growing group of unfortunates afflicted with hay fever, a number of whom are tenants and employees in our building.

As an illustration we might cite the case of a young girl who wished to attend a commercial school domiciled in our building. She told the school president that she didn't expect to accomplish much during the summer because of her hay fever. However, she found so much relief in the clean atmosphere that she came to school as early and stayed as long as she was permitted. In two other instances—one a tenant, the other our employee—winter vacation periods were chosen in lieu of summer because greatest relief was found from their affliction at

their desks in our air conditioned building.

These statements of fact relating to the health of our occupants logically lead us to other comparisons which we would like to make in regard to our experience in our own organization concerning the physical welfare of our employees before and since our installation of air conditioning equipment.

Flu—Previous to 1936 we accepted as a matter of course the fact that we would have to struggle through the colder months with frequent decreases in our force, varying from 10 to 15 per cent. Cold and influenza epidemics would take their toll and we would be helpless. Since 1936 our loss of time from sickness due to these causes has been reduced to just an occasional case. Surely four years is sufficient time to demonstrate that this change is not merely a coincidence.

Good Investment

Now these blessings of air conditioning are not mere luxuries. Neither are they purely the outgrowth of humanitarian impulses. They are both of these, perhaps, if one wishes to take such attitude, but primarily they are good solid investments that yield splendid dividends. This is the answer to the question, "Why do so many insurance companies install air conditioning equipment?"

Insurance companies are probably neither more nor less indulgent with luxury for employees, or humane treatment of them, than any other line of business—so this cannot be given as the reason for their acceptance of air conditioning. The investment return realized from the increased efficiency and reduced loss of time is the real answer and stands out conspicuously when you analyze the nature of the business.

Effect on Personnel—In the first place, insurance is a technical business. Every business man realizes the importance of an experienced personnel, but in the insurance field much of the work requires years of training for satisfactory performance. Extra help is not a practical way to solve a peak load situation, and for that reason a healthful environment is most essential since it contributes substantially to uninterrupted service of the regular employees. Furthermore, the peak load of an insurance company falls during the less healthful winter months when the huge annual statements must be prepared, and it is in this work that the highly trained employees are the most indispensable.

No layman can appreciate the tremendous volume of work required of the home office staff in the insurance business during the year end rush, but anyone who has had such experience will readily testify that any device which is conducive to regular attendance of employees is most attractive. To him no additional proof need be given that the acceptance by insurance companies of air conditioning equipment is not governed by any self-indulgent motives, but is dictated by the principles of sound business judgment. It may also be said in general that the more technical the business, the greater is the return realized on this modern improvement since the skilled operating personnel is in the higher salary brackets and the increased efficiency and regular attendance have a direct bearing on profits.

Effect on Machines—Of course insurance companies enjoy but do not have a monopoly on the general benefits of air conditioning—such as closed windows resulting in reduction of street noise, absence of flies

Above—Insurance companies enjoy an additional air conditioning benefit because so much of the work is mechanized, and with clean air whose humidity is controlled the machines operate better. This composite view shows (1) the telephone switchboard, (2) photostating, (3) record files, (4) stenographic detail, (5) duplicating punch for policy file cards, (6) a corner in the ladies' lounge, and (7) mechanical sorter for policy file cards

SUMMARY—Impressed by the number of insurance companies that have invested in air conditioning for their own home office buildings, the editors queried a number of insurance executives to find out just what they thought of this modern improvement. Mr. Schwenker's article is one of the results. . . . He explains the advantages of air conditioning observed at the home office building of Lincoln Liberty Life Insurance Co. since it was modernized in 1936. Efficiency of trained employees, highly important in the busy winter months, has been improved through reduction in colds, influenza, etc. Hay fever sufferers find relief in summer. Business machines operate better in a conditioned building; this is particularly important in insurance offices, as they are highly mechanized

and other insects, clean desks and papers free of wind-blown dust, removal of the danger of valuable papers being blown away by drafts from open windows, etc. However, insurance companies do enjoy a distinct air conditioning advantage because so much of the office work is mechanized. The machinery is naturally kept clean easier and functions better with air conditioning. The cards are maintained properly, since a balance is kept in humidity and they are less apt to jam the machines. A disabled machine causes loss of time on the part of skilled employees and again you establish the point previously made that the more technical the business the greater is the return on air conditioning investments.

The System

Our air conditioning system consists of three 25 hp, six cylinder compressor units in the basement. They are fully automatic and operate alternately. On each floor is a floor type air conditioning unit with a capacity of 5000 to 6000 cfm of air and with a refrigeration capacity of 12 to 15 tons. These units clean the air, cool or heat it, and dehumidify or humidify it, depending upon the season.

In the penthouse is a supply fan with a capacity of approximately 10,000 cfm; all the outside air is brought in by this fan. In summer this air passes through a precooling coil and in winter through a heating coil. An automatic air filter is used to clean the air. During the heating season it is humidified after it leaves the heating coil by a steam humidifier placed in the air passage. The humidifier is controlled by a humidistat.

The architects for the modernization were Meginnis and Schaumberg, the consulting engineer in charge of air conditioning was Walter E. Gillham, and the plant was installed by Wentz Co., Inc.

Air Raid Shelter Ventilation

A NEW branch of ventilation that has come prominently to the fore during recent times is that of air raid shelter ventilation.

The home office regulations dealing with this matter define "air raid shelter" as meaning protection otherwise than by war-like means or by any article of apparel, from hostile attack from the air, and "an air raid shelter" as being any premises, structure or excavation used or intended to be used to provide air raid shelter.

Shelters may vary in size and capacity from half a dozen people to several thousands and in design from a plain concrete structure at ground level to a most elaborate deep level shelter or series of shelters incorporating lavatories, control rooms, alternative systems of electric supply, heating, lighting and air conditioning together with full protection against poison gas.

The regulations lay down that any shelter accommodating more than 12 persons must be mechanically ventilated if for every person:

The floor area is less than 6 sq ft.

The cubic capacity is less than 50 cu ft.

Where permanent sealing against gas obtains, the air allowance is 150 cu ft air per person per hr if the above floor area ratios, etc., are not exceeded or 450 cu ft air per person per hr if they are exceeded. In the case of shelters accommodating less than 12 persons, the above figure of 6 sq ft per person may generally be reduced to 3¾ sq ft.

For shelters containing 25, 50, or 100 persons, electric-with-manual unit sets can, with advantage, be used but for shelters having above this capacity, combination fan and motor units with distributing ductwork is recommended.

One ARP shelter, the ventilation for which has been designed by the author, has capacity for accommodating 2000 persons, the shelter being formed as sub-basement to a large block of new offices. The construction of the shelter is calculated to be sufficiently strong as to withstand a direct hit on the office premises above, resulting in complete collapse of the eight story office building above. In another case, the shelter has capacity for 5000 to 7000 persons, and comprises a series of deep level tunnels, suitably sectionalized and connecting with the various works buildings they are designed to serve. In both cases, adequate mechanical ventilation has been provided for and all the necessary home office precautions taken to meet emergencies.

Detailed designs or data cannot, for obvious reasons, be given, but tests carried out on many shelters of widely different design and capacities have amply demonstrated the home office regulations as giving satisfactory comfort conditions under the most adverse circumstances.

This applies to the purely mechanical, as well as the electric-with-manual installations.

The lighting restrictions caused by ARP regulations have resulted in many complications arising with regard to the effective ventilation of buildings such as power station engine rooms, foundries, gas works, retort houses, large machine and erection shops in engineering works, etc.

It is quite a usual practice in such places as the above, either to provide air movement by extract or fresh air inlet fans with natural inlet or outlet as the case may be, through open windows or doors. ARP restrictions prevent the use of such natural means and a very satisfactory solution has been found in the adoption in window spaces of electric propeller supply or extract fans combined with a special light shield consisting of light restricting baffles and similar in construction to the light shield used in normal ventilation work for photographic dark rooms.

Such light filters offer practically no resistance to the normal flow of air and their adoption has been proved a complete success in a number of installations.

Taken by permission from a paper by C. Gordon Huntley published in the Journal of the [British] Institution of Heating and Ventilating Engineers, Vol. 8, No. 89.

Chicago Tribune photo

New Electroliners Offer

Comforts of Air Conditioning

THE Chicago North Shore & Milwaukee Railroad recently put into operation the first all-electric articulated trains of their kind to be built. Known as "Electroliners", they were specially designed to meet the peculiar needs of the heavy daily traffic between the metropolitan areas of Chicago and Milwaukee. They are four unit articulated trains, 155 ft long, the four units being mounted on five trucks—a departure from the conventional practice of putting trucks at each end of a car and then joining the cars with standard couplings.

The entire structure, including floors, sides, roofs and ends, is insulated with 3 in. of insulation material; even where the interior finish is attached to the body structure the metallic path is broken by means of insulation. To further assist in reducing heat and sound transfer, the trains are equipped throughout with double sash at each window opening.

Heating

The new trains are air conditioned and temperatures are under thermostatic control. Heating comes from two sources. Floor heating is supplied by unit strip electric heaters in a duct along each side of the train below the seats, and thermostats for control of floor heat are situated under the seats to insure desired temperatures at this level. Additional heating is provided by banks of fin strip electric heaters in the ventilating ducts adjacent to the fans, so that this part of the heating is combined with the ventilating.

Ventilation

There are two ventilating fans driven by one motor situated above the headlining over the entry way on each of the end units and above a section of the headlining at the end of each of the center units. Each set of two fans discharges 1100 cfm of air into the ventilating ducts, above the center of the ceiling and extending the entire length of each car.

During the heating season 400 cfm of outside air is drawn through an air filter by each set of ventilating fans and mixed with 700 cfm of inside air which is also drawn in through a filter. This mixed air is passed over the fin strip heaters and into the ventilating ducts. Thermostats which control the temperature of this air are situated inside the ducts at the opening farthest from the heater banks.

Cooling

During the cooling season the same fans and air ducts are used as during the heating period. Air is cooled and dehumidified by being passed over cooling coils in the air ducts immediately adjacent to the heater banks. Cooling thermostats are in the duct where the recirculated air is drawn into the ventilating system, and control solenoid valves which regulate the amount of "Freon" entering the evaporators. Control of each of the two compressor units is such that the compressor is operated if either of the two evaporators requires more refrigerant.

Two compressor-condenser units are used, one under each of the center units. The liquid refrigerant to and the gaseous refrigerant from the evaporators in the end units is carried in jumper hoses between the train units.

EXPLOSION HAZARDS

in

Hospital Operating Rooms

V. L. Sherman Explains the Background of the Problem, Tells of Work Being Done to Solve It

"If I shall speak too freely, grant to me Both pardon and indulgence."

AN announcement was made in HEATING, PIPING AND AIR CONDITIONING some months ago that the Chicago Committee on Air Conditioning Standards had contributed $200 to help defray expenses in connection with research contemplated on the causes and elimination of explosion hazards in hospitals. There is a story in connection with this action which should interest air conditioning engineers and contractors. As secretary of the committee which was to make use of this fund, the present writer has delayed an account of the matter until reports and results were in prospect. Research projects are, as you know, deliberate affairs.

Bear in mind, please, that the writer is speaking only for himself, and that until a short time ago he was a professor. This is mentioned because professors, in being required to know it all, sometimes make gorgeous mistakes. [One professor of transportation in identifying the initials on the Plimsoll mark, which indicates the various seasonal load-lines of a ship, called "I S" the "Indian summer line," whereas it really is the summer load-line for the Indian Ocean.] So, in this you must be prepared for anything.

"Modern anesthetic gases are known to be more hazardous in their use than the old drop ether method." That statement is not correct. Modern anesthetic gases, so far as ultimate results are concerned, may be far safer. So far as explosion hazards are concerned, during an operation, their use may be no safer than that of the ether drop. As to fire hazards it would seem a toss-up. The real hazard, to my mind, is the danger of delay in progress due to exclusion of a modern anesthetic gas from a hospital following an explosion in the operating room when that gas is used. On occasion explosions do occur, perhaps once in nearly half a million operations. There is the temporary panic. Lawsuits loom. The majority of hospitals are in no position financially to make much of a fight. To avoid further risk of publicity that gas may be withdrawn from use. The pressure is too much. And there is little of the dramatic if a patient dies more or less peacefully a few days after an operation. The point is that there may be less hazard of explosion during an operation if the older methods of anesthesia are used, but there may be a much reduced final hazard if the modern gases are used.

The problem is to prevent even an occasional explosion, and to preserve the use of these gases. Anesthesia should be improved, not blocked.

Cause of Explosions

The veil of mystery which seems to surround one of these explosions or "accidents" is a natural protection for the hospital. Evidence produced and testimony given in any suit for damages is rarely factual. Whatever the cause, the hospital is bound to be accused of negligence.

It is generally agreed that the most common cause of explosion is the discharge of static electricity within the hazardous zone. This zone is thought to be within a few feet of the mask on the patient's face or where there may be an accumulation of explosive mixture about the operating room. Since explosions are much more rare in those sections of the world where high natural humidity exists, and are more frequent when naturally high static conditions exist in cold weather, most of the mystery is cleared away. It is true that there are other causes for these explosions, but for the time the question is mainly how to prevent the accumulation of static charges, or how to avoid differences in potential about the operating room. Research has been done in this. The first means toward prevention that might be proposed by an air conditioning engineer would be to maintain a certain percentage of relative humidity so that gradual lowering of electric pressure would take place, and to provide sufficient ventilation, well controlled, to prevent any accumulations of explosive mixtures. At the same time anything in the way of drafts should be eliminated. So far, excellent. But from reports that may be considered conservative, it would seem that explosions have occurred in operating rooms where the percentage of relative humidity is greater than 60.

There are two schools of thought among the anesthetists in connection

SUMMARY—The real hazard in the use of modern anesthetic gases in hospital operating rooms lies, the author believes, in the possibility of its exclusion following an explosion when one of them is used. The problem, he says, is to prevent even an occasional accident and to preserve the use of these gases. Anesthesia should be improved, not blocked, in other words....A committee to study the subject of explosion hazards in operating rooms was recently formed, and air conditioning is well represented in its membership. Mr. Sherman, secretary of this committee, explains here for the first time the reasons for this work and how it is being carried on....The subject is a highly important one, and is of special interest because of the part played by air conditioning, particularly in the maintenance of proper relative humidities as an aid in preventing sparks

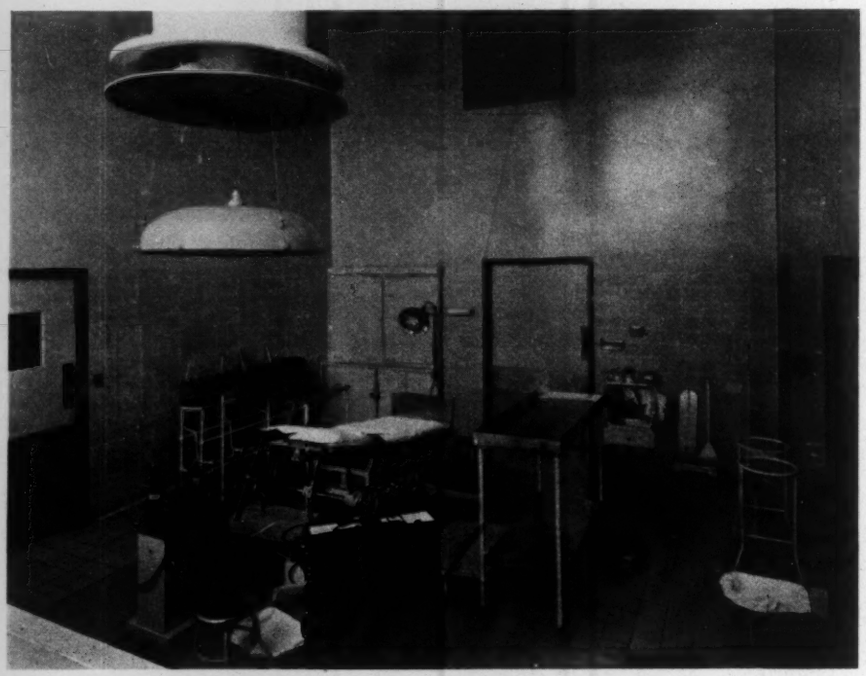
with this static spark problem. One group has been convinced that everything within the operating room which might accumulate a charge of static should be grounded through a suitable resistance, and that equipment and those about the operating table within the hazardous zone should be intercoupled so that no differences in potential may exist. In severely cold weather there is every chance of producing great differences through careless handling of clothes, coverings and equipment. The personnel are trained to avoid this danger, and the extremely low "accident" rate proves that extreme care is used.

The other school believes that there should be no grounding, that grounding may create an extra hazard. This group depends upon the thorough training of the anesthetist and care in the handling of the apparatus and the patient. There is one noteworthy feature about the training of this second group. They are taught to accept full responsibility and to believe that no one and nothing is foolproof.

Committee Formed

A little over a year ago a group came together in Chicago and chose a committee which they thought could at least investigate the causes of these explosions in an unbiased way, and determine what steps might be taken to avoid them. The committee is composed of six doctors, two of whom are anesthetists of high rank, two architects who specialize in hospital design, an expert on the handling of explosive gases, an expert in fire prevention, and an expert on explosion hazards. Also there is a gentleman, a doctor, who discovered and brought into use one of the most modern anesthetic gases. He would not patent it. The Institute of Medicine of Chicago thought well enough of this committee to place it among their several committees, and to offer their rooms for the committee's deliberations. Pages could be written about the independent vigor of the Institute of Medicine of Chicago, but this institute needs no praise.

Referring now to Chapt. 32 of the ASHVE's Heating, Ventilating, Air Conditioning Guide, you will find the statement: "Grounding the various parts of the anesthesia apparatus is not entirely effective, so long as rubber remains in use in the conventional equipment. Some form of grounding within the apparatus may be a partial solution." Ordinary rubber is the "ebony in the woodpile." It so happened that before this committee was organized, one rubber manufacturer was having exhaustive tests made on what was called "non-static" rubber for use in oil truck tires. It was suggested that, should the rubber prove itself an electric conductor, that floors, pads, casters, and hose for the anesthetic gas machine be made of it. To make a long story short the manufacturer and a maker of anesthetic gas machines were taken into a corner and asked if they would consent to furnish a room at the Underwriters' Laboratories with flooring, gas machines, and the new rubber equipment, to be dealt with as the committee pleased. They were to furnish the materials, but were not asked to contribute to the additional cost of the investigation, and there were to be no strings tied to it. They did consent, with complete generosity. That investigation has been going on since last fall. The Underwriters' Laboratories have shown every consideration, and it is understood that a report will be made shortly. The $200 provided by the Chicago Committee on Air Conditioning Standards has paid for this investigation.



An excellent example of operating room air conditioning is seen at Billings Hospital at the University of Chicago. During autumn, winter and spring, design conditions are 74 F dry bulb and 57 to 60 per cent relative humidity. In summer, design conditions provide for maintaining 55 to 60 per cent relative humidity and a 16 F differential between inside and outside temperatures during maximum summer conditions, although under ordinary operation 12 F is the maximum differential used. Samuel R. Lewis was the consulting engineer for this project

A Great Field

The elimination of some of the hazards through the use of conductive rubber is one great step, but the job of preventing explosions in the operating room does not end there. The study is a long one. But it may be here pointed out that perhaps a great field for air conditioning engineers lies in work for the hospitals. This is just as important as work in the industries, and more important than comfort control.

Since last September, the quartermaster corps has purchased 43,981 "heaters" for $4,084,012 and 373 boilers for $1,308,414, the war department announced last month. The heaters range in size from the small units used in tents, to the larger ones used for heating barracks and other similar buildings. The boilers are used to provide heat and power for hospitals, laundries, and as central heating plants.

A Method for

REDUCING FUEL CONSUMPTION

H. P. Scott, Assistant Supervising Engineer of Large Real Estate Management Firm, Explains Method Which Has Saved Thousands of Dollars

IT is accepted practice to record and compare the annual fuel consumptions of buildings on a degree day and cubic foot basis. By so comparing buildings with other properties of similar construction, occupancy, cubical capacities and hours of service, it has been possible to deduce the *relative* efficiency of any one property in the light of *average* performance. The yardstick of comparison becomes more exact as the number of buildings in the comparison increases and, should all of the considered properties be truly similar, an inefficient plant will soon rear its dollars-per-unit head above the norm like a financial sore thumb. After being thus spotlighted, the ailing plant may well profit by resultant consultation, diagnosis and prescription.

Looking over the record of past seasons, however interesting, cannot alter established facts and, if faulty operation has resulted in excessive fuel consumption, a post-mortem review will not eliminate the excess. Summer investigations to determine winter ills are not always productive of effective results, inasmuch as the diagnosis of a cold, idle or lightly loaded plant does not usually coincide with the observations made while the symptoms are severest.

Mid-Season Checking

It is necessary, therefore, to devise some method for frequent, mid-seasonal checking to effectively "ride herd" on straying Btu's and to maintain a check-rein on heating wastes.

This system must be comparatively simple and one in which interpolations can easily be made. The mechanics should be worked out during slack seasons so that quick deductions are possible in the heating season. Detection of waste and inefficiency at the start or in the midst of a heating season may lead to important savings before the boilers are opened for their spring inspection.

Accurate tabulations of oil, gas and street steam consumptions are made simple by the use of meter and gage readings. Coal records are subject to greater error because the average plant is not equipped with the facilities accurately to measure the weight of coal, volume of feedwater or steam generation. It is possible to estimate closely the amount of fuel in the bin by calculating that the approximate space occupied by a ton of coal is between 35 to 36 cu ft.

Making such an estimate at the beginning of every week or month and keeping a record of deliveries within the several periods enables the engineer to obtain a close approximation of the fuel actually consumed during any desired interval. Monthly reports should be a minimum requirement of all superintendents and larger plants have recognized the wisdom of reducing this interval to a week and, in some cases, a day. Making an annual report discovers the waste, if waste has existed, only after the dollars have been "drafted" up the stack. The lock on the heating barn door is fastened only after the horsepower has been stolen.

SUMMARY — Although it is accepted practice to record and compare annual fuel consumptions of buildings on a degree day and cubic foot basis, it has been found that pre-season predictions and mid-season checks help detect fuel waste more effectively than post-season records. Locating and correcting faults during instead of after the season shows up possibilities of immediate savings and presents a picture more true to life for study than is the case when the analysis is made during the summer shutdown. . . . . Mr. Scott, Assistant Supervising Engineer, Brown. Wheelock, Harris, Stevens, Inc., New York real estate management organization, discusses here a method which has led to an over-all fuel consumption reduction of 16 per cent on a total annual fuel bill amounting to three-quarters of a million dollars. The data given are based on a study of 250 buildings under the jurisdiction of this firm. In a second article, Mr. Scott will give specific suggestions, supported by actual cases, on how to make savings

Theoretical Ideal

Knowing the actual monthly consumptions of oil, gas, steam or coal, we next must compare the result with both past performances, average efficiency and a theoretical ideal. This is necessary because past performances and consumptions in buildings of like cubes and construction may easily be in error due to the same faults which we are trying to detect through the medium of our records. The theoretical ideal is included to reduce guesswork to the minimum.

A review of 250 buildings under jurisdiction of the firm with which the author is connected—160 coal fired, 40 heated by street steam and 50 oil fired—over a six year period indicates that the consumption of various fuels approximates the figures given in Table 1. The "per cubic foot" applies to buildings in the New York metropolitan area, subjected to an annual heating season of 5300 degree days. The "per 1000 cu ft per degree day" figure should apply in any location.

To illustrate the application of a theoretical ideal, consider the 69 gal of oil per 1000 cu ft per season required for apartments. Roughly,

one-third or 23 gal is devoted to the creation of hot water while the other two-thirds or 46 gal is consumed in the manufacture of heating steam. Since the hot water demand is fairly constant throughout the year, the 23 gal should be divided by 12, indicating that approximately 1.9 gal of fuel oil is consumed every month for every 1000 cu ft contained in a first class apartment house.

The 46 gal of heating oil should be apportioned according to the degree days in the various months. The average of 60 years' records for metropolitan New York, compiled by the U. S. Department of Agriculture, furnishes the basis for Table 2.

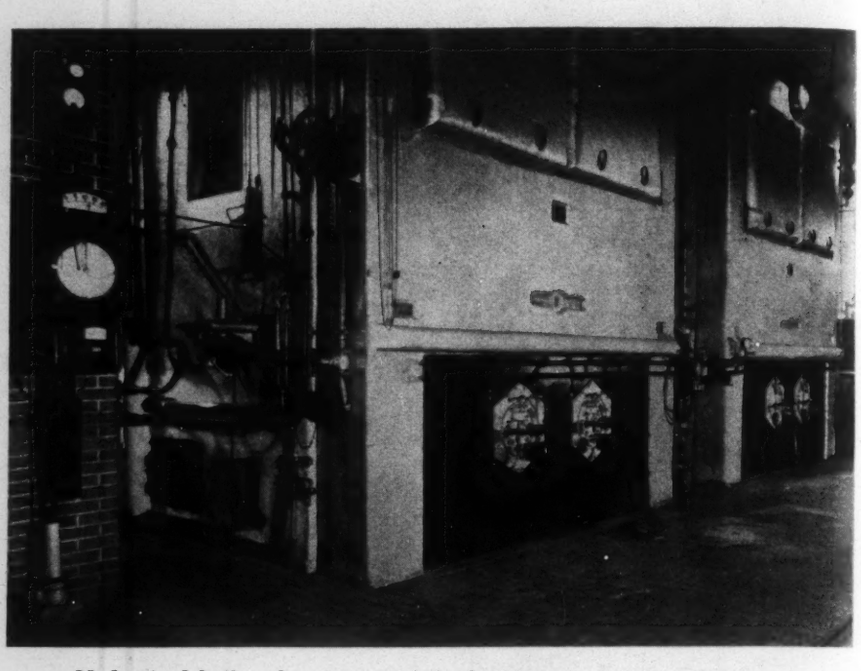
Forecasting Fuel Consumption

Example: An apartment house with a cubical capacity of a million cubic feet should approach an annual consumption of 69 x 1000 or 69,000 gal during a normal season of 5300 degree days, 23,000 gal being used in the production of hot water and 46,000 gal being used for heat. Should the season be more or less severe, 1/53 of the heating oil (868 gallons) should be added or subtracted for every 100 degree days by which the seasonal or monthly total is exceeded or reduced.

In Table 2 it is indicated that the average month of January contains 1060 degree days or 19.96 per cent of the seasonal total. The apartment house mentioned should anticipate a consumption of 9190 gal for heating and 1920 gal for hot water, or a total of 11,110. When the weather reports for January are compiled and, should it prove that the actual degree days exceeded the anticipated 1060 by 50, the theoretical consumption should be increased by 434 to 11,544 gal and the result compared with the actual consumption as computed by the delivery and tank gage records. Similar tables may be compiled for steam and coal but the above example shows the possibilities of such a check.

Since the base figures of 6 lb of steam, 0.9 of coal and 0.069 gal of oil are all on the liberal side, it is possible that many buildings will fall well within the limits set by this schedule. However, the figures are the results of actual plants in practice and it is safe to assume that, in any general group, the percentage of records passing this rough check will be small.

Should the actual consumptions exceed the theoretical standards by 10 per cent or more, a complete survey of the plant is urgent for the best interests of the building.



Modernized boiler plant in one of the buildings included in the group discussed in this article. Note the CO_2 recorder, an aid to operation

Correction Factors

Factors which affect the accuracy of this method are numerous but it is possible to cut the theoretical cloth to fit the physical pattern of the building in question.

Consumption is increased 15 per cent if the building is on a corner instead of having but one front exposure and a building with frontals on three sides consumes 25 per cent more than the base figures. Method of firing (hand or stoker); type of fuel (bituminous or anthracite coal, light or heavy oil); accessories such as automatic draft controls and blowers; percentage of occupancy; and submerged hot water coils—all have their bearing.

For the past six years the foregoing procedure has been followed to plot a progressive month-by-month efficiency graph of the 250 buildings previously mentioned. The oil, coal and steam involved costs three-quarters of a million dollars annually.

Table 1—Fuel Consumption for Heating

Building	Per Cu Ft per Season			Per 1000 Cu Ft per Degree Day		
	Steam	Oil	Coal	Steam	Oil	Coal
Lofts	3 lb	0.04 gal	0.4–0.5 lb	0.6 lb	0.008 gal	0.11 lb
Offices	4	0.05	0.6–0.7	0.8	0.01	0.15
Apartments (with hot water)	5-6	0.069	0.8–0.9	1.1	0.014	0.20

Table 2—Fuel Oil Consumption for Apartments

Month	Degree Days		% of Total DDs		Gal per 1000 Cu Ft			% of Total Gal	
	Monthly	Cumulative	Monthly	Cumulative	Heating	Hot Water	Total	Monthly	Cumulative
Sept						1.92	1.92	2.8	2.8
Oct	280	280	5.30	5.30	2.43	1.92	4.35	6.3	9.1
Nov	625	905	11.75	17.05	5.42	1.92	7.34	10.6	19.7
Dec	930	1835	17.53	34.58	8.06	1.92	9.98	14.4	34.1
Jan	1060	2895	19.96	54.54	9.19	1.92	11.11	16.1	50.2
Feb	945	3840	17.83	72.37	8.21	1.92	10.13	14.7	64.9
Mar	844	4684	15.93	88.30	7.32	1.92	9.24	13.4	78.3
Apr	469	5153	8.85	97.15	4.06	1.92	5.98	8.7	87.0
May	147	5300	2.85	100.00	1.27	1.92	3.19	4.6	91.6
June						1.92	1.92	2.8	94.4
July						1.92	1.92	2.8	97.2
Aug						1.92	1.92	2.8	100.0
Total	5300		100		45.96	23.04	69.00	100	

Poor operation is quickly detected and prompt corrective measures have resulted in an over-all fuel reduction of 16 per cent.

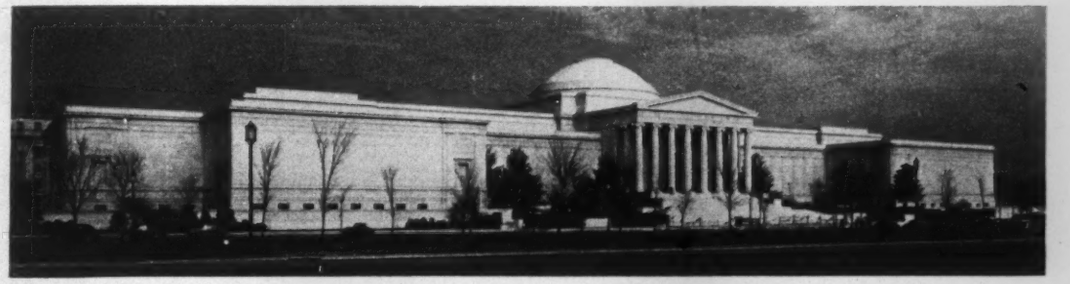
Segregate Hot Water

It is often the case that heat controls, orifice systems and similar equipments are installed which affect only the heating system. Arrangements can be negotiated whereby the improvements are paid for as the savings resulting from such improvements are realized. Since the equipment affects only the heating factor of the total consumption, the hot water load should be eliminated in calculating fuel decrease and the percentage of saving. Likewise, the installation of submerged coils would affect only the hot water and the heating equivalent if possible should be disregarded when results are tabulated.

Like all "rules of thumb," the system presented here for predicting monthly consumptions is no criterion for all cases. Standards have been taken to cover loosely the entire field, but adherence to this or a similar practice is certainly a step in the right direction and should show great improvement over the "punt-pass-pray" system which many "boiler room quarterbacks" advocate.

[A second article by Mr. Scott will suggest how fuel consumption for heating can be reduced. He will give actual examples of results achieved in various buildings.]

National Gallery of Art Completed

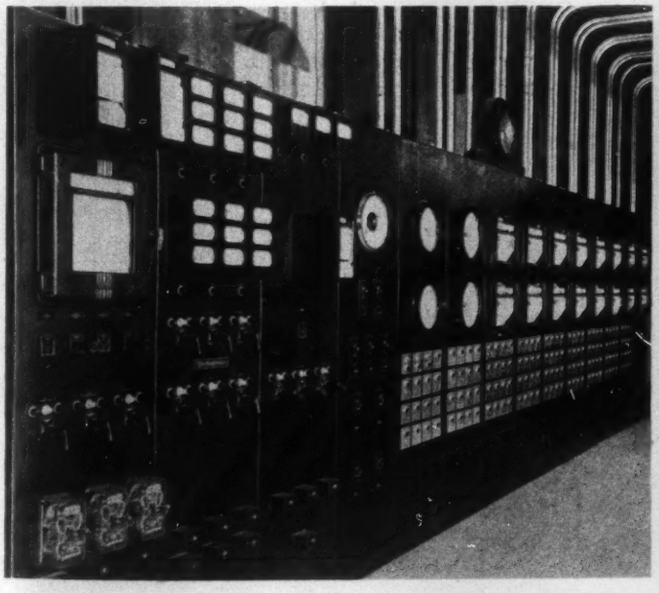


The National Gallery of Art, Washington, D. C., gift of the late Andrew W. Mellon, is to be formally accepted for the Nation by President Roosevelt the evening of March 17. This view shows the Mall front, which stretches for three blocks and is slightly longer than the Capitol and its wings. The consulting engineeer was Clyde R. Place, the architect was the late John Russell Pope (1874-1937), associates Otto R. Eggers and Daniel Paul Higgins.

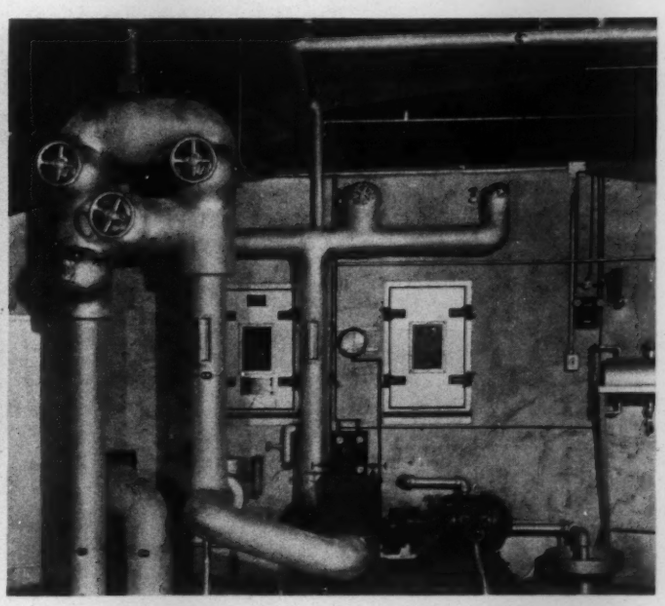
The building is air conditioned in order to protect the priceless art treasures from damage due to changing temperatures, humidities and dirt, and for the comfort of visitors and the staff. Three centrifugal refrigeration machines having a total capacity of 1020 tons serve the air conditioning system, which is divided into 21 units. It is planned to maintain 50 per cent relative humidity the year around, with temperatures between 70 and 80 F. The spray water is chemically treated to remove sulphur dioxide from the air, which would otherwise injure the paintings.

A special supply and exhaust system is installed to give a rapid air change in the space between the lay lights, used instead of a ceiling, and the skylights. Otherwise, the temperature in this space would rise to excessive levels due to sun heat, which would put a very much increased load on the air conditioning system.

Shown at the lower left is the central control panel—the brains of the air conditioning system—and at the lower right is a view of a typical air washer unit.



Underwood & Underwood



Underwood & Underwood

Advances in Textile Drying

RECENT advancements made in the drying of textiles were described by Fred Kershaw, Proctor & Schwartz, Inc., at the recent annual meeting of the American Society of Mechanical Engineers. He pointed out that in the most modern type of raw stock dryer, cotton is being dried in 1¼ min, about ⅛ the former time. The new equipment has a capacity of 50 per cent more than even the most recent stock dryers and over 100 per cent greater capacity than older types.

Describing improvements in other textile drying fields, Mr. Kershaw said in part:

"In the dryer for skein yarn a recent development increases the productive capacity of the dryer, and at the same time prevents snarling and damage. This development is a protector or skirt which travels with the skeins of yarn as they pass through the dryer and prevents them from touching or rubbing against the sides of the machine. The use of this traveling protector permits the loading of the skeins right out to the ends of the poles.

"Until a few years ago mercerized cotton warps were dried on cans or cylinder dryers. Now, practically every mercerizer in the country is equipped with one or more rolling festoon dryers, in which the warp is dried by heated air instead of direct contact with heated metal surfaces. The result of the use of this dryer has been a more elastic yarn, a rounder yarn, and a fuller count.

"In another piece goods dryer, which is at present in the experimental stage, the cloth is conveyed by the air stream. There is nothing essentially new in conveying by air, but the problems involved in finding a method of precisely controlling the air currents have been difficult to solve. In operation this dryer feeds itself as fast as the metering rolls at the feed end will permit. Adequate circulation is provided on both sides of the cloth. Therefore, there is no tendency toward shading, which is troublesome with certain types of dyes and finishes. Furthermore, with no continuous contact with any surface there is no marking of finished goods. Not enough commercial data are available to estimate the value of this machine properly.

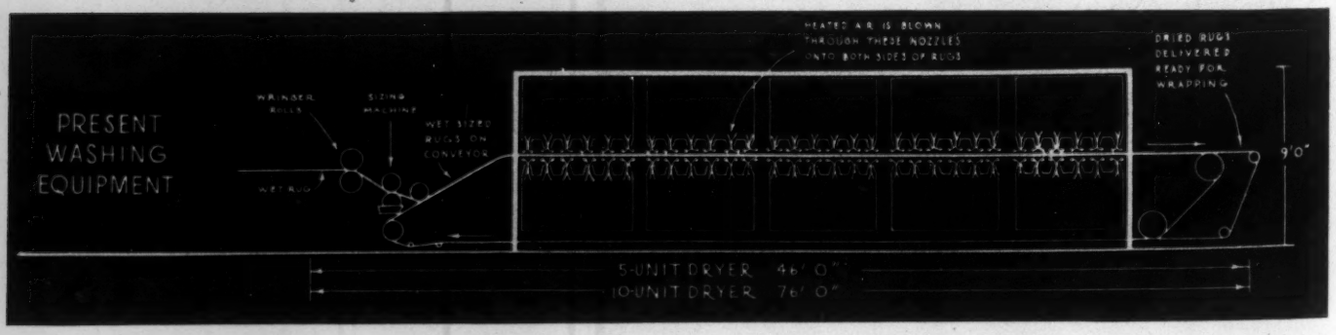
"The fastest commercial drying machine at present in operation for piece goods is the straight run, high speed tenter. In this machine, because of extremely high air velocities, 5 yd cotton piece goods can be dried in approximately 10 sec.

"In another interesting dryer under development, piece goods going through are held in a series of small loops between two conveyors. Air jets blow on both sides of the goods so there is an absence of shading. A possible use of this machine, which has not as yet been demonstrated fully, is for shrinking. Thus far the residual shrinkage of the cloth running on the experimental machine has been reduced to a very small amount.

"Another new development in dryers is a machine used for drying washed rugs. It is wide enough to take a rug 17 ft wide. The washed rug, after being thoroughly rinsed with water, is lined up and fed through squeeze rolls, from whence it is automatically carried through the size rolls where an even coating of cold water size is deposited on the back of the rug. Leaving the sizing rolls, the rug is picked up automatically by the main conveyor of the dryer. A soft rubber roll presses the rug down on small pins in the main conveyor. These small pins, which are not unlike Victrola needles, hold the rug over its entire area and prevent shrinkage during drying. As the rug travels through the dryer, high velocity jets of air impinge on both sides and the rug is dried horizontally as it would lie on the floor. The natural tendency of the rug to shrink results in a tentering effect and produces a finished rug, the equal of a new rug in body and floor holding qualities. Whereas in the average rug cleaning plant a drying time of 15 hr is required, in this machine a drying time of only 15 min is necessary.

"Recently, interest has been aroused in the possibilities of drying by means of infrared radiation. Reduced to its simplest form, this merely means drying with radiant heat instead of heated air. For any substantial amount of heat energy to be transferred by such radiation the radiant member must be at a high temperature, such as the filament of an electric light bulb. To a large degree, heat is transferred from the hot filament to the object to be heated without materially heating the air between the filament and the object. Air movement is unnecessary in this type of heat transfer, although it may be necessary to have just enough air velocity to remove the surrounding air, which becomes saturated with the evaporated water."

Automatic machine for squeezing, sizing and drying washed rugs


PRESENT WASHING EQUIPMENT
WRINGER ROLLS
SIZING MACHINE
WET SIZED RUGS ON CONVEYOR
WET RUG
HEATED AIR IS BLOWN THROUGH THESE NOZZLES INTO BOTH SIDES OF RUGS
DRIED RUGS DELIVERED READY FOR WRAPPING
9'0"
5-UNIT DRYER 46' 0"
10-UNIT DRYER 76' 0"

SOUTH AMERICAN WAY

on this Buenos Aires job was to

USE A HEAT PUMP

Melvin A. Ramsey, Arnott & Co., Ltd., Buenos Aires,

Describes Reversed Refrigeration Plant in a Theater

THE economic advantages of a "heat pump" or reversed refrigeration cycle installation for heating a building depend upon a number of factors. It is very doubtful if such an installation has ever been justified as a heat source alone, because the improved heat output over actual fuel input can in general hardly justify the investment in plant necessary to make the higher output possible. The use of mechanical refrigeration for air conditioning, however, makes the plant available and it then becomes a question as to whether or not fuel costs for heating, power costs and performance factor obtainable in the particular installation, justify the use of the refrigerating plant for heating the building.

In many localities, particularly where power is purchased, the performance factor possible is far too low to bring the power cost with a heat pump as low as the fuel cost with a conventional type of heating plant. In other localities conditions are more favorable; Buenos Aires is one of them. In discussing the subject from a general standpoint, and in describing the details of an actual installation, the centigrade and metric units are transposed to the Fahrenheit and British system (gallons are U. S. gallons).

The Buenos Aires climate varies from a record minimum of about 23 F to a record maximum of about 104 F. In summer the design dry bulb and wet bulb for air conditioning should be about 95 F and 75 F, respectively, so that a fair sized refrigerating plant is necessary. Add to this the fact that well water at 64 to 68 F is available at a depth of about 75 ft and conditions for a heat pump are about all that one could desire.

Probably the first installation of this kind in Buenos Aires was made in a 700 seat moving picture theater—"Cine Novedades." The maximum summer load was calculated to be approximately 579,000 Btu per hr, or about 48 tons, and the maximum winter load as 325,000 Btu per hr. With such an installation, we have a perfect set-up for a heat pump installation. Climate and well water conditions were all that could be asked and a theater requires much less heating in winter than refrigeration in summer. Also, the same large volume of air used in summer need not enter at a very high temperature to take care of the winter heat loss even when the theater is empty.

Improved Load Factor

The owners wanted a completely automatic system, even to the change-over from summer to winter operation. The control was somewhat further complicated by the

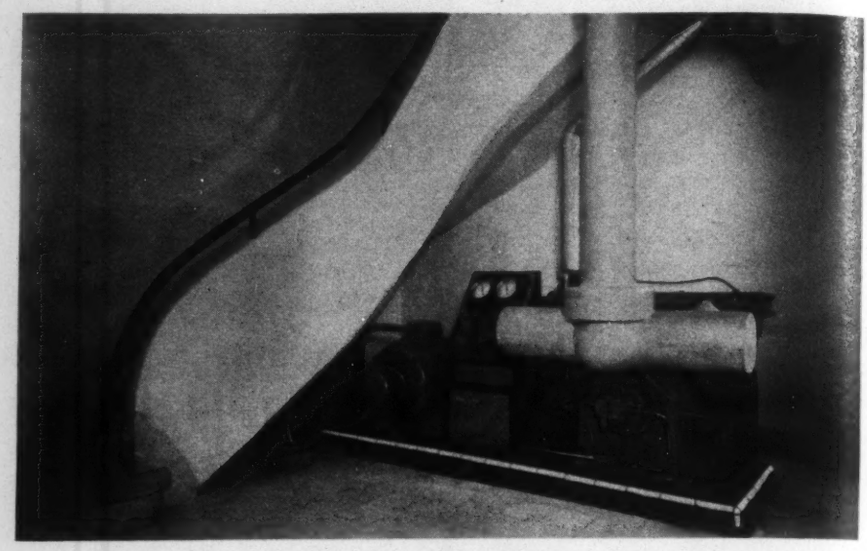
SUMMARY—Where a refrigeration plant for summer air conditioning is available, there is the possibility of using the reversed refrigeration or heat pump cycle for heating in winter. The advisability of so doing depends of course upon fuel and power costs, performance factor obtainable for the particular installation, the relationship between the summer cooling load and winter heating load, etc. . . . An installation of this kind in a 700 seat motion picture theater in Buenos Aires is described here. In this case the climatic conditions, available well water, and the summer and winter loads were favorable to the idea. The equipment is described in some detail—it incorporates some unusual points—and a table of hours of operation and kilowatthours for heating and cooling for a nine month period is presented. . . . For further information on the reversed refrigeration cycle for heating, see the two articles by A. J. Lawless published in the August and September, 1940, issues of HPAC

"Cine Novedades," 700 seat motion picture theater in Buenos Aires, is heated by the refrigerating equipment which cools it in summer

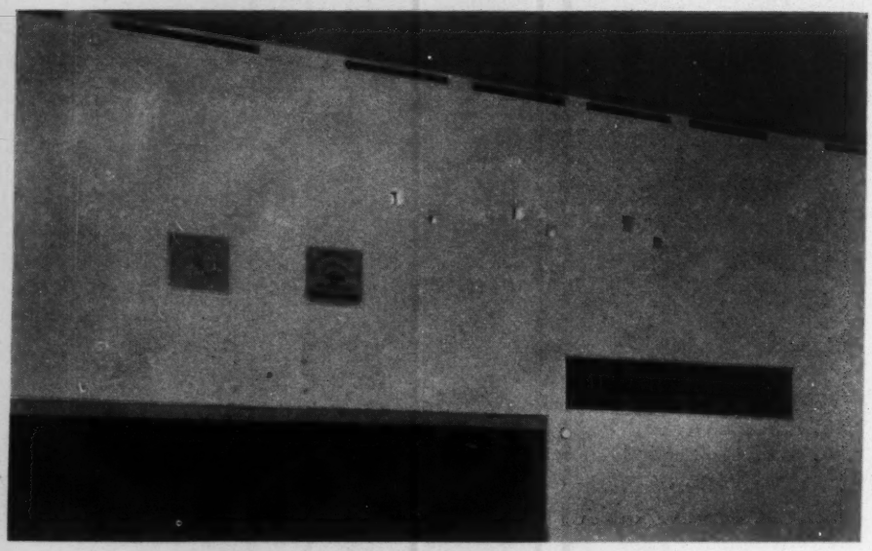
necessity of recording the compressor and well pump power consumption on one meter while it was heating and on another while it was cooling, due to the owners desiring separate data on the power consumption for heating. No special power rate was obtained, but probably a slightly lower one will be available in the future as this current can be sold at a lower rate because it improves the year 'round load factor when, without requiring a larger connected load, more kilowatthours are used.

[*Note*—The question of a lower rate for such a use of power would naturally depend upon the local rate structure.—ED.]

As air conditioning becomes more prevalent it is probable that the summer load will be greater than the winter load and the power companies will be more anxious for additional winter load even at slightly lower rates. In the particular district where the plant described is installed there are a number of other theaters and the summer load in this locality exceeds the winter load at present—so that plants such as that described are welcome to the power company.



The compressor, which provides about 48 tons capacity for cooling in summertime



Rear wall of the theater, showing supply outlets at top and return outlet at right center

Condenser and Evaporator

The automatic change from summer to winter operation on a job of this size appeared simpler if the refrigerant circulation remained the same and the air and the water circuits were changed, because automatic valves for "Freon" of 4 in. diameter were not available. We, therefore, used finned copper tube coils for both condenser and evaporator. These are arranged so that by means of automatic dampers the air can be made to pass over the condenser while the water passes over the evaporator or *vice versa*. The method of circulating the air in order to remove heat from the condenser or add heat to the cooler, was, of course, very simple but the circulation of water over the coils in such a way as to be certain of a proper heat transfer, without making the system too complicated, required careful study. It was finally decided to use horizontal coils for both condenser and evaporator having a casing around each with dampers above and below for control of the air circulation.

Above each coil, at a point sufficiently high to avoid interference with air passage when the particular coil was using air circulation, a copper pan was installed, the bottom of which has an area equal to the coil face area. This bottom is perforated with a large number of fairly closely spaced, small diameter holes. The diameter and number of holes is such that with the 88 gpm of well water delivered to the pan, the water will leave as fast as it enters. This results in a uniform "rain" over the whole coil surface. Actually there are in this case about 9000 holes of slightly less than $\frac{1}{16}$ in. diameter in the bottom of each pan. The bottoms of the pans are sufficiently reinforced to assure that they will be approximately level. The use of copper eliminates corrosion and the well water is filtered, just before discharge, through a screen having openings far smaller than the perforations in the pans.

It might be wondered why standard spray nozzles were not used and so arranged that the water would be properly distributed over the coils. This was considered but since about 10 lb per sq in. pressure would be required for the nozzles, the well pump would have required about 0.8 hp additional.

Details of Equipment

The actual heat pump circuit consists of condenser, evaporator, compressor and accessories as described below. Import duties were respon-

sible for some of the designs and it is probable that some of the details would be different were all standard materials as manufactured in the United States available in Buenos Aires at the same prices as in the United States. However, the methods used to overcome our special problems will, no doubt, be of interest.

Compressor—This is a four cylinder 5 in. x 5 in. machine running at about 470 rpm at full load, having automatic suction valve unloaders to permit operation on one, two, three or four cylinders. For heating it is never necessary to use more than one cylinder. All four are often used for cooling.

Condenser—This is composed of 1155 ft of ¾ in. OD copper finned tubing arranged in 40 parallel circuits between a 3 in. header for the gas and a 2 in. header for the liquid. The face area is 33.2 sq ft, the inside or "Freon" surface is 202 sq ft, and the outside or air surface is 1870 sq ft.

Evaporator—This has 1250 ft of ¾ in. OD copper finned tubing arranged in 30 parallel circuits taken from a 2 in. liquid header; they end in an 8 in. suction header which serves as a "steam drum." This arrangement gives assurance that the refrigerant will be evenly distributed throughout the coil and that there will be no liquid carry-over. In effect we have a "water tube boiler" with a "steam drum" in which a float valve feeds all available "Freon" to the "boiler." It is then only necessary to charge sufficient refrigerant to cool all the tubes and about an inch of the "steam drum." The face area of this coil is 20.5 sq ft, the inside, or "Freon" surface is 219 sq ft, and the outside or air surface is 2030 sq ft.

Counterflow Water Coil—The 3320 cfm of outside air passes over a counterflow coil through which the 65 F well water circulates before going to the condenser or evaporator. Since it is very unlikely that cooling will be used when the outside air is below 65 F or heating used when it is above 65 F, this coil is always helpful and more so in times of peak demand for either cycle of operation. This coil has a face area of 8.2 sq ft. an inside surface of 75.2 sq ft, and an outside surface of 695 sq ft. By means of this coil the outside air is cooled from 95 F to 71 F, assuming no latent heat reduction, or raised from 32 F to 60 F.

Control

Summer—The compressor operates at 25, 50, 75 or 100 per cent capacity as called for by the return air thermostat.

The discharge pressure varies from about 90 lb at 25 per cent to 110 lb at 100 per cent. Without an additional control the suction pressure would be too high at partial capacities. The control provided bypasses recirculated air as required to maintain a constant coil surface temperature. Fundamentally a thermostat opens the bypass with a rising surface temperature. This control permits use of all of the evaporator surface at all times and assures that the rates of latent to sensible heat removal will be approximately constant. The use of all evaporator surface at partial capacities results in a higher efficiency than if part of the coil were cut out.

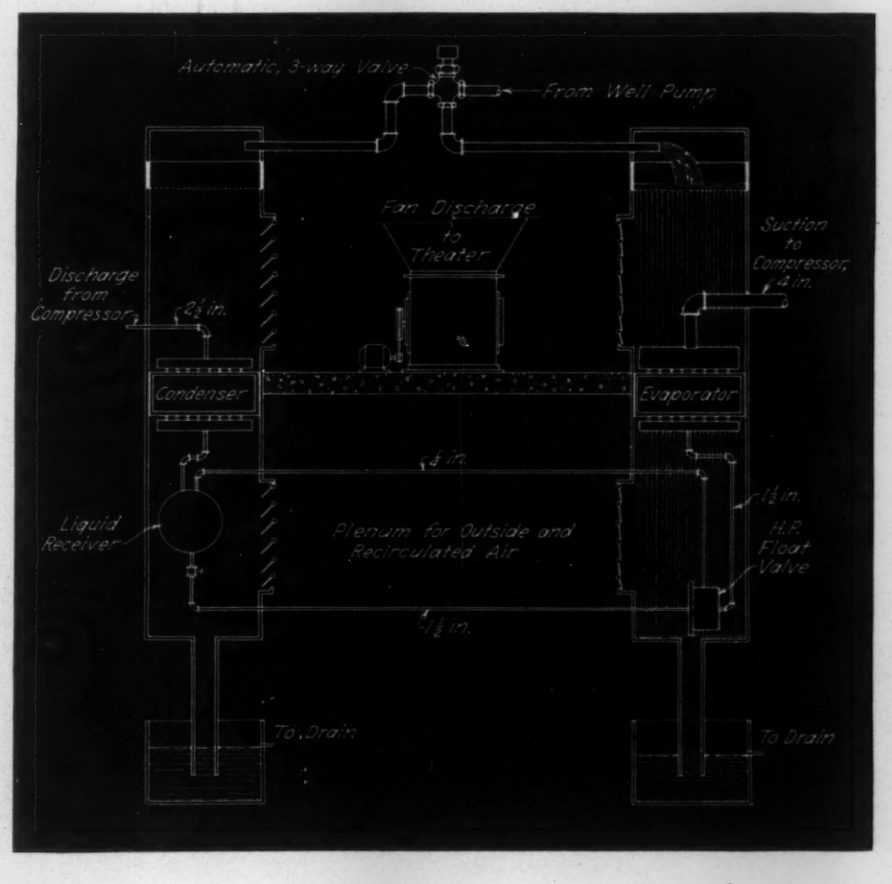
This method of humidity and temperature regulation has been entirely satisfactory. A patent covering it has been applied for in the United States and in Argentina. In this particular installation, with a surface temperature of about 45 F, the suction pressure varies from approximately 25 to 35 lb.

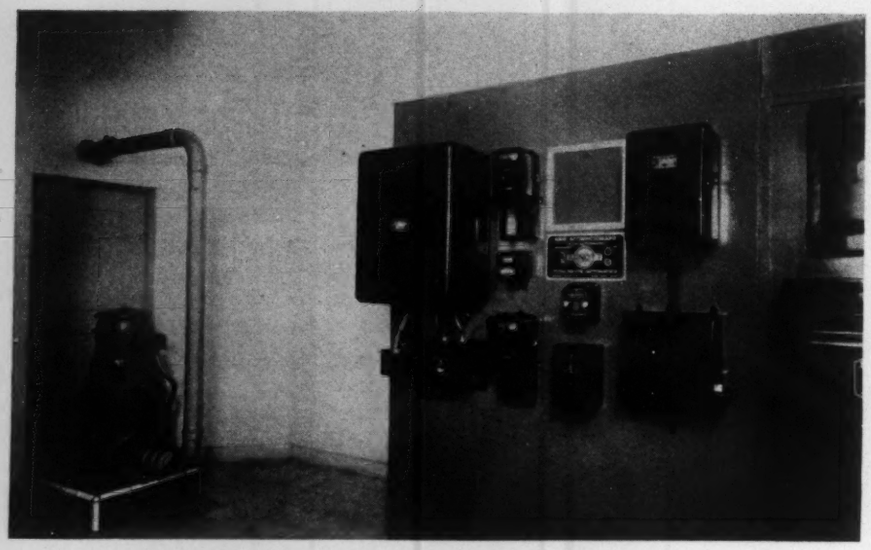
Complete records have been kept of operation; hour and kilowatthour meters integrate the various items.

Readings were taken at least every two or three days (most of the time daily) of hours of fan operation, hours of compressor operation for heating, hours of compressor operation for cooling, kwhr of compressor and well pump for heating, kwhr of compressor and well pump for cooling, and total kwhr of air conditioning plant. Records were begun on August 5, 1939, (exactly the middle of winter) and continued to April 30, 1940. The results are shown in the table.

The change from heating to cooling is by means of a large damper motor which also changes a mercury switch to actuate a small five pole; double throw relay. One pole of this relay shifts from one hour counter to the other. Two poles

Schematic diagram of heat pump installation for a theater





The well pump and control panel

connect the two voltage coils on the heating meter to the third line or disconnect and short circuit the same voltage coils depending on the cycle. The other two poles perform the same function with the cooling meter. This saved magnetic switches to change the current coil connections. With this arrangement the current coils of both meters are always in circuit but the meter whose voltage coils are connected is the only one which indicates. It may not always be necessary to short circuit the voltage coils not in use but where the lines to the relay pass close together for some distance the inductance may cause a slight forward or backward meter movement unless the disconnected line from the voltage coil is joined to the same line as the other end of that coil.

This installation has outdoor compensated temperature control and in addition, to improve economy, a differential thermostat actuates a damper motor to cause the use of all outside air if at any time during the cooling cycle the outside wet bulb temperature is lower than the return air wet bulb temperature. The plant is operated from the projection room where a pushbutton starts the fan and a white light indicates its operation. The choice of heating or cooling or neither is automatic.

A red light in the projection room indicates the compressor operation for heating and a blue light indicates its operation for cooling. This completely automatic operation makes for more comfortable conditions because on days when only a little heating or cooling is required it is taken care of automatically, whereas it would probably be neglected if it depended upon manual operation.

There have been a few days when a cool morning required heat for the nearly empty theater and the higher temperature outside and crowded theater later required cooling on the same day. This flexibility is obtained without any thought on the part of the operator.

Hours and Kilowatthours for Heating and Cooling

Month	Hours			Kilowatthours		
				Compressor and Pump		
	Fan	Heating	Cooling	Heating	Cooling	Total
Aug. 1939	230	37.1	.....	585	.....	1,680
Sept. 1939	220	73.1	.....	1,347	.....	2,462
Oct. 1939	215	31.0	20.0	393	357	1,655
Nov. 1939	276	14.9	59.4	245	1,209	2,891
Dec. 1939	318	3.7	122.9	56	2,457	4,517
Jan. 1940	364	1.3	276.0	22	6,669	9,143
Feb. 1940	401	0.4	229.4	8	5,129	7,653
Mar. 1940	400	35.5	118.9	602	3,266	6,374
Apr. 1940	369	70.6	59.5	1,417	2,031	5,706
9 Months	2,793	267.6	886.1	4,675	21,118	42,081

Note—Buenos Aires winter occurs during U. S. summer.

AIR CLEANING HELPS BOOST BUSINESS

EXTENSIVE building renovation, including the installation of a 15,000 cfm electrostatic air cleaner, has resulted in an average attendance increase of 40 per cent for Hamilton, Ontario's, Alexandra skating rink. Cleaning costs have been considerably reduced because less frequent cleaning is needed; tobacco smoke and skating powder dust have been removed from the interior atmosphere.

Dust and Smoke

Before modernization, the skating and dancing hall was troubled by bad dust conditions in the air. On dance nights, it was almost impossible to see from one end of the 150 ft long building to the other due to the blue tobacco smoke haze. The condition was even worse on skating nights, because the fine chalky powder which is placed on the floor to prevent side-slipping of the skates was agitated by the skaters and whirled around in the air.

The 20 air cleaner cells are installed in a single bank in a penthouse just outside the main hall; ducts carry the clean air from there into the ceiling space, where it enters the hall through ceiling grilles. Return grilles are also situated in the ceiling. All duct work is concealed. Although, for the most part, recirculated air is employed, outside air may be injected when required.

Attendance Up

The greatest benefit has been increased attendance. On Saturday dance nights, attendance has risen from 700 or 800 to 1000 or 1200. On week skating nights, including the Wednesday dance night, attendance has risen from about 500, to 700 or 800 people. Though this attendance increase is due in some part to the general re-decoration of the hall, the clear freshness of the interior atmosphere has played a major part. Added revenue is expected to exceed the cost of the air cleaner installation very shortly.—A. E. Agnew, Engineer, Livingston Stoker Co.

AIR CHANGE—

Once a Major Criterion

C. M. Ashley* Blasts the Use of "Air Change", Hopes It May Soon Be "Gone With the Wind"

SUMMARY—Mr. Ashley's object here is to show that despite the age of the venerable term "air change," it deserves no reverence but rather should be exorcised from our practice. He concludes—on the basis of his discussion—that: (1) "air change" not only cannot be used properly to describe room air circulation, but also that its use even in a limited range is likely to result in drafts; (2) it works in reverse as a criterion of ventilation; and (3) it is the poorer choice for crude estimating. . . . HPAC's editors would be happy to hear from HPAC's readers what they think about this term, its advantages and disadvantages

THE use of "air change" to determine the air handled by an air conditioning system or brought in from the outside is as venerable as the industry itself. I propose to show that despite its age it deserves no reverence; rather we should exorcise it from our practice as a malignant growth.

"Air change" has been used, when analyzed to its essence, primarily for two purposes: (1) to express the air movement in the conditioned space, and (2) to indicate the amount of outside air which should be introduced. Usually it is used to set empirical limits on the amount of air introduced to a conditioned room in terms of the room volume. For instance, I have heard statements by its apologists that you shouldn't have an "air change" of less than 4 min or more than 20, meaning that the volume of air handled by the air conditioning system should equal the room volume within those limits.

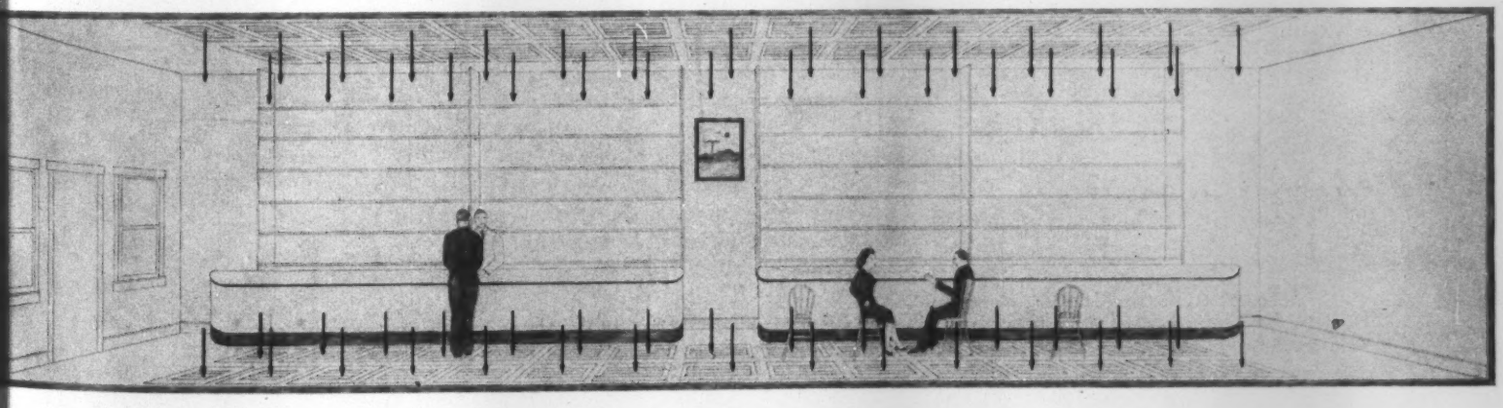
*Director of Research, Carrier Corp.

Air Movement

Let us first examine the air movement angle. To do this, let us assume a room 20 ft by 100 ft by 12 ft high, or 24,000 cu ft volume. It is our purpose to keep within the limits of 15 to 50 fpm velocity of the air in the occupied zone of the room, recognized as good practice to avoid drafts and yet avoid stagnation. First, let us assume 24,000 cfm being handled by the apparatus, a 1 min "air change" and way above the "allowable" limit of "air change." This air quantity is much larger than ordinary practice requires but for certain means of distribution it still can be introduced properly. We will introduce the air evenly over the whole ceiling of the room at low velocity and draw it out through a large number of points distributed over the floor, Fig. 1. The velocity will theoretically be 12 fpm, or below our permissible minimum. However, there will probably be enough obstructions to bring it up to 15 fpm or more. While such a system of distribution is probably not altogether practical, it may be closely approximated in practice. With such a system you could go to three "air changes" per min before exceeding the maximum permissible room velocity.

Next, let us assume air is being delivered overhead from one end of the room at 2000 fpm velocity, Fig. 2, which is necessary to deliver the air the length of the room. At this velocity the air from the apparatus will induce and set in motion a total of about 10 times its own volume. Due to the blocking effect of the discharge air stream and furniture and people, the return air must flow back through about 70 per cent of the cross-sectional area of the room. Thus, the velocity of the return air stream is about 14 times the apparatus cfm divided by the cross-sectional area of the room. On this basis, 860 cfm from the apparatus builds up to a velocity of $860 \times (14 \div 240)$ sq ft $= 50$ fpm, the maximum permissible. This gives an "air change" of 28 min, which is again outside the permissible limit—but this time on the other side.

Fig. 1—With this method of air distribution, you could go to three air changes per min before exceeding maximum permissible room velocity



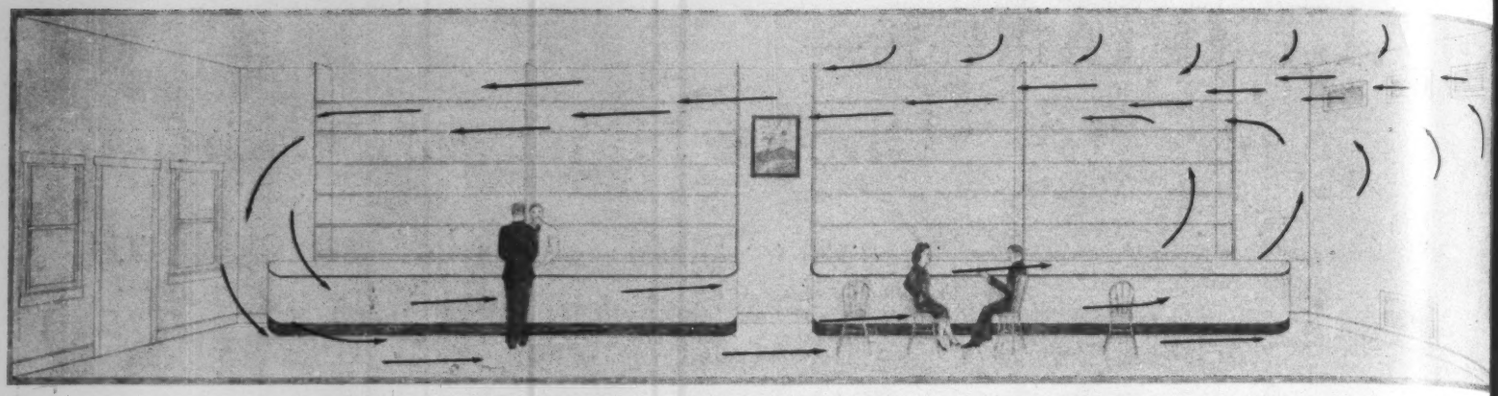


Fig. 2—And with this method of air distribution in the same room as in Fig. 1, a higher air change than one in 28 min will exceed the maximum permissible room velocity

Thus, by changing only the method of introducing the air to the room we have obtained two results each outside the opposite limits of the "air change" range. Not only would the use of the "air change" criterion have resulted in a loss of flexibility in the selection of equipment, but it would also have given unsatisfactory results in these two cases. Actually, of course, the limitation of air quantity is determined by the amount of air required to carry the cooling and heating effect to the room. It is always possible to increase the room circulation by increasing the outlet velocity without fundamentally altering the method of distribution to the room. Sometimes, however, (as in the second example), the velocity of the outlet must be high to carry the air the length of the room. Usually in this case the cross-section of the room is small in relation to the air volume from the apparatus. The result is frequently too high a velocity in the occupied portion of the room.

For 50 fpm velocity with reasonably uniform distribution from a side wall and with no more than normal blocking of the room cross-section, the criterion for maximum cfm is:

$$\frac{7200 \times \text{Room Cross-section in Sq Ft}}{\text{Outlet Velocity}}$$

Again, a local velocity may result from too great a concentration of the return air to the apparatus, yet the "air change" criterion is of no help in this problem.

Amount of Outside Air

If we consider the second use of the "air change" criterion, for determining the amount of outside air to be used, it is apparent that the real factors are the magnitude of the sources of contamination of the air and the standard of freedom from contamination which it is desired to maintain.

It is now generally agreed that odor rather than carbon dioxide content is the determinant of ventilation requirements. Odors arise primarily from the body odors of the human occupants, from the smoke of the tobacco which they use and from the food which they eat. To a lesser extent odors may also emanate from leather, furniture, drapes, books, etc. The primary criterion for ventilation is, therefore, not how much space there is in the room, but rather how many people there are, from what level of society (do they bathe frequently?), how much they smoke and are they eating and if so, what? You would not need four times as much ventilation air for the same standard of ventilation in a 40 ft ballroom as you would with the same people for a 10 ft high chophouse. Quite the contrary—it has been shown that less ventilation is needed with the high ceilinged room. First, there is the storage effect of all the extra air in the higher room which dilutes the odors and slows down the rate of rise of the odor level. This factor is particularly effective in a space having short periods of occupancy. Second, it has been shown (by Yaglou, about 1937 or 1938) that many odors are ephemeral and tend to disappear of themselves. Thus, by increasing the ratio of room volume to people, more room and therefore more time is allowed for the odors to disappear by themselves—therefore, less ventilation air is required.

Crude Criterion

There is some small use of "air change" as a crude criterion of heating or cooling load. Where accuracy must be sacrificed in extreme degree in the interest of simplicity of calculation, there would seem to be some place for such a criterion, but there are others which are but little more involved which are distinctly better. For instance, for homes or offices the use of the outside wall and roof areas certainly is more accurate and not greatly more complicated.

* * *

I hope that the foregoing analysis has been sufficient to explode "air change" completely and that it may soon be "gone with the wind."

[The editors will welcome communications from readers on this subject for publication in our "Open for Discussion" columns. What do you think of "air change"?]

Despite wars and depressions, civilization does progress, at least in some fields. For example, a restaurant and bar advertises its new "Black Hole of Calcutta Room, completely air conditioned for your comfort." This seems prime evidence of progress, although a "Black Hole of Calcutta Room" is probably the one type of place which, to live up to its name, shouldn't be air conditioned, for the "Black Hole" tragedy—cited in many a text on ventilation and air conditioning—was one of the most striking examples of the effects of poor air conditions. Into a cell 15 ft by 18 ft in a fort at Calcutta, 146 English prisoners were thrust the night of June 20, 1756; next morning 123 were dead for lack of ventilation, excessive heat and humidity.

"Open for Discussion"

Communications to the Editor

Horsepower for Compressors

THE EDITOR—

As pointed out in the article by William Goodman in the December HPAC, computing the horsepower of refrigerating compressors from tables of horsepower per cubic foot of refrigerant vapor circulated eliminates variables outside the compressor itself which would affect the results if figured from tables of horsepower per ton of refrigeration. Calculations made on the latter basis would be correct only for the conditions of pressure, temperature of the liquid to the expansion valve, and temperature of the suction vapor for which the table had been made up, and for other conditions corrections would have to be made.

The value of horsepower per ton of refrigeration is, however, still of great interest since it is a measure of the overall operating efficiency of the plant. This value can, of course, readily be calculated by dividing the horsepower by the tons refrigeration.

I agree that the theoretical values of horsepower per cubic foot are independent of subcooling of the liquid refrigerant ahead of the expansion valve and of the superheat of the refrigerant vapor entering the suction port of the compressor, providing that the gamma value of the gas remains constant. There is evidence, however, that the actual horsepower per cubic foot is affected by the superheat condition of the suction gas. Wolfert (Refrigerating Engineering, Vol. 39, No. 61) found that the power input to a group of compressors tested decreased with rising superheat. Whether this would be true of all types and sizes of compressors is a question, but I want to point out that the power requirements are not necessarily independent of the condition of the suction gas.

In the equation the value of E_p might be a variable function with the superheat and it is quite likely also a variable function of the suction and discharge pressures. As the article states, it can be determined only by experiments on the compressor under consideration.—LEON BUEHLER, Engineering Dept., Frick Co.

Ventilation for Electroplating

THE EDITOR—

Thank you for the advance copy of the article "New Data for Practical Design of Ventilation for Electroplating," which was published in the February HPAC. I appreciate your thoughtfulness in sending me the material.

I had the good fortune of observing the work at first hand several months ago and had looked forward to the publication of the results. I consider the paper a distinct contribution to the science of local exhaust ventilation.—J. M. DALLAVALLE, P. A. Sanitary Enigneer, in Charge Environmental Sanitation Section, Division of Public Health Methods, National Institute of Health, U. S. Public Health Service.

Steam or Hot Water for Process Heating?

THE EDITOR—

We have a problem which we have not found easy to solve. I am therefore taking the liberty of referring it to you in the hope that you may have sufficient information available, either theoretically or practically, to supply an answer.

Our problem is not a new one, and is simply "What are the relative merits of steam and high pressure hot water in process heating from the aspects of (1) control of temperature of the process, and (2) economy of operation?" By high pressure hot water I mean at a boiler pressure of between 100 and 150 lb per sq in. and working under a system having main delivery and return pipes from and back to the boiler, circulation being maintained with a centrifugal pump. The steam pressure could be similar or as low as 40 lb per sq in. absolute.

I visualize two types of process heating which may affect the answer. On the one hand there is the plant having only one process, such as a timber drying kiln, which is relatively close to the boiler and where the condensate (if steam heated) can be returned back to the boiler at a high temperature through a steam trap and finally a condensate return-to-boiler system (such as the overhead tilting trap system whereby pressure is temporarily equalized in the boiler and the tilting trap to permit accumulated condensate periodically to run back into the boiler). On the other hand there is the plant having a number of widely separated processes from which it would be difficult to return all condensate (if steam heated) back to a boiler but which could be fitted into a piping layout using circulating hot water. The question is "Would either or both of these possible arrangements be more economically heated by steam or by the high pressure hot water?"

I trust I am not asking too much in requesting an opinion on the above query. HEATING, PIPING AND AIR CONDITIONING is regularly routed through our division and we feel that you could tell us quite a lot.—G. W. W.

REPLY (by SAMUEL R. LEWIS, Consulting Mechanical Engineer. Member of HPAC's Board of Consulting and Contributing Editors)—The question seems to imply that heat for process purposes only is to be supplied from combustion of fuel in a boiler which is devoted to process purposes only. It also implies that the temperatures desired do not exceed those obtainable from steam at a moderate pressure and that the condensate is to be returned to the boiler.

Air, water or any other suitable material may be heated by contact with a warm surface and that surface may be heated by steam or by water or by dry gases. The temperature difference between the surface and the heat receiver is the major significant condition. Therefore the answer should be governed by consideration of convenience and by the

efficiency of the heat transporting medium.

If water is used there will be no minimum temperature short of freezing, and the maximum temperature will be that of the steam at the same pressure. The water, at boiler pressure, generally can be circulated with less power than is required by a condensate pump.

Since the same water recirculates, once having deposited its solids on the boiler, there will be no further precipitation. No automatic air valves or thermostatic traps are necessary, and the heat transmitters may be below the boiler without prejudice. The water temperature for the whole system or for each separate department may be modulated by throttling the volume, or by mixing part of the hot water coming from the boiler with part of the recirculated water.

Fuel economy is promoted when the recipient of the heat, against the boiler surfaces, is relatively cool.

Thus water circulating mechanically and at high speed around the hot surfaces in a hot water boiler will be at a mean temperature many degrees cooler than the thermally circulating water in a steam boiler.

For the above reasons my reply to the question favors hot water for process heating under the conditions stated.

Effect of Air Velocity on Wet Bulb Readings

THE EDITOR—

Do you have any information on the effect of velocity on wet bulb readings?

The only information that I have been able to obtain so far is from a bulletin entitled Standard Method of Rating and Testing Air Conditioning Equipment, published by the American Society of Refrigerating Engineers. On p. 18 of this bulletin the following table appears:

MEAN ERROR IN WET BULB TEMPERATURES

Air velocity over wet bulb, fpm	Error, per cent
2000	0.6
1000	0.9
500	1.4
200	2.5
100	4.0
50	6.0

Correction = t' — per cent error $(t - t')$, in which t and t' are dry and wet bulb temperatures respectively.

At a velocity of 500 fpm, where one generally assumes that no correction is necessary, the value from this table would be $t' - 0.014\ (t - t')$ which is very close to the general radiation correction of $t' - 0.016\ (t - t')$ in which the 1.6 per cent factor remains constant. Is this merely a coincidence, or are radiation corrections included in the velocity corrections?—E. H., Engineer.

REPLY (by WILLIAM GOODMAN, Consulting Engineer, The Trane Co. Member of HPAC's Board of Consulting and Contributing Editors)—The radiation correction for wet bulb temperature does vary with the velocity of the air past the bulb. The use of the constant value of 1.6 per cent dates back to Carrier's[1] classic 1911 ASME paper. Although he showed that the radiation correction varied with the velocity, he suggested the use of an average correction of 1.6 per cent based on the use of an ordinary 15 in. sling psychrometer revolving at between 150 and 225 rpm, which corresponds to a velocity of between 1200 and 1800 fpm. In a later ASME paper published in 1924, Carrier and Lindsay[2] further investigated the radiation correction of wet bulb thermometers and the table showing the radiation correction at various air velocities which is published on p. 18 of the ASRE bulletin entitled Standard Method of Rating and Testing Air Conditioning Equipment is based on their work. More recently, Dropkin[3] has investigated the effect of radiation on wet bulb readings.

Although the question has not been raised in regard to the temperature of adiabatic saturation, it might be well to point out that Carrier's basic formula and practically all psychrometric charts are based on the temperature of adiabatic saturation—not on the wet bulb temperature. For water and air, the difference between the two is very small. Nevertheless, if measurements precise enough to require radiation corrections are being made, the true temperature of adiabatic saturation should be used.

The temperature obtained by means of a wet bulb thermometer shielded from radiation—or an unshielded thermometer corrected for radiation—is lower than the true temperature of adiabatic saturation. On the other hand, because of radiation an unshielded thermometer will indicate a temperature higher than the true temperature of adiabatic saturation at all air velocities below approximately 1000 fpm. At about this velocity, an *unshielded* wet bulb thermometer will indicate almost the true temperature of adiabatic saturation because the effect of radiation just about cancels the difference between the true temperature of adiabatic saturation and the wet bulb temperature indicated by a *shielded* wet bulb thermometer. Consequently, insofar as subsequent psychrometric computations are concerned, at air velocities of about 1000 fpm, more accurate results are obtained by ignoring the radiation correction. For a further discussion, see the papers by Carrier and Mackey,[4] and by Dropkin.[5]

Readers of HEATING, PIPING AND AIR CONDITIONING are invited to contribute their views to these "Open for Discussion" pages, which will appear from time to time. Comments on articles we have published, expressions of timely interest on developments in design, installation, operation or maintenance of heating, piping or air conditioning systems, other remarks of value to HPAC's readers—all will be welcomed by THE EDITOR.

Piping Flow Problems

THE EDITOR—

This is to acknowledge and thank you for the extra copy of the article "Piping Flow Problems Made Easy" from the October HPAC.

Since receiving this article, a great many men in our engineering department have indicated their desire to obtain copies for their own use. Consequently, we would appreciate receiving two dozen more copies of this article.

Kindly address your reply to the attention of our engineering librarian.—E. J. K., Assistant Engineering Manager.

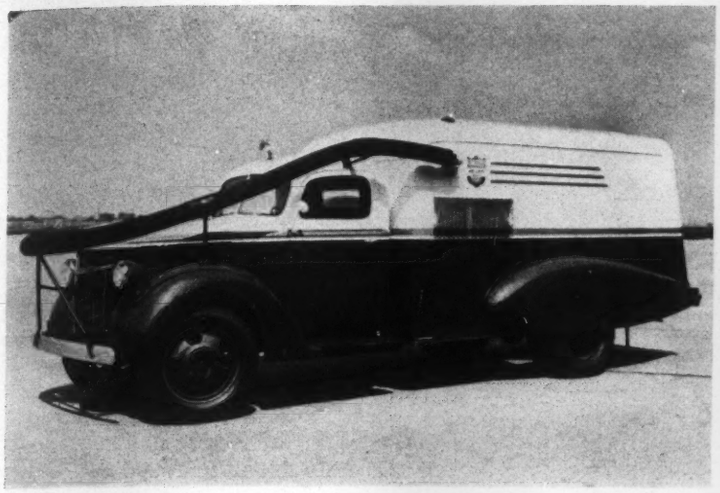
[1] Rational Psychrometric Formulae, by W. H. Carrier, Transactions, ASME, Vol. 33, 1911.

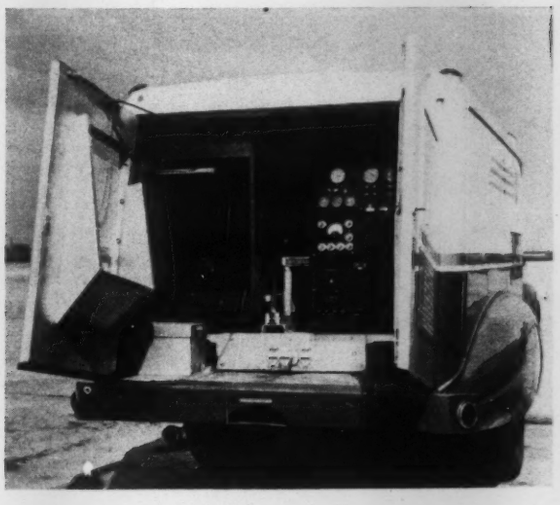
[2] The Temperatures of Evaporation of Water into Air, by W. H. Carrier and D. C. Lindsay, Transactions, ASME, Vol. 46, 1924.

[3] The Effect of Radiation on Psychrometric Readings, by David Dropkin, Cornell University Engineering Experiment Station, Bulletin No. 26, October, 1939.

[4] A Review of Existing Psychrometric Data in Relation to Practical Engineering Problems, by W. H. Carrier and C. O. Mackey, Transactions, ASME, Vol. 59, January, 1937.

[5] The Deviation of the Actual Wet Bulb Temperature from the Temperature of Adiabatic Saturation, by David Dropkin, Cornell University Engineering Experiment Station, Bulletin No. 23, July, 1936.





Air conditioning truck unit for heating or cooling planes on the ground. A gasoline engine-generator set drives the refrigeration compressor through a power take-off and generates current for operating the fans. Heating is by circulating hot water from the engine jacket through coils and by electric heaters. Air is conveyed to the plane by the large hose

From 0 to 15,000+ Feet

W. W. Davies of United Air Lines Describes Plane Heating and Cooling on the Ground and at High Flying Altitudes

SUMMARY—In an article in the January, 1941, HPAC, Mr. Davies, Project Engineer, United Air Lines Transport Corp., discussed the general problems of heating and ventilating commercial airplanes. He supplements his previous article this month with a description of heating and cooling planes on the ground, and cabin supercharging for flight at extremely high altitudes. . . . As airplanes do not have fans for forced air circulation, but depend upon the ram effect when in flight for their ventilating air, special truck units for heating and cooling the planes on the ground are used. . . . For flight at high altitudes, the supercharged cabin has been developed to maintain a pressure inside the cabin greater than outside, thus eliminating the difficulties which have sometimes been experienced with oxygen deprivation

THERE is no independent means in an airplane of forced air circulation such as is accomplished in trains or buses by use of a blower or fan. Therefore, when the airplane is on the ground, the cabin temperature is normally the same as the outside air temperature, and with a plane standing in the hot sun, the cabin temperature may rise to as high as 135 F. Consequently, with the plane at the station, provision must be made to cool the cabin in summer and heat it in winter by some auxiliary means. A satisfactory type of unit incorporates both heating and cooling equipment, as well as a source of emergency electrical power. The entire assembly is mounted on a special truck for general ease in maneuvering to the plane. One of the latest designs of such equipment as now operated by United Air Lines is illustrated.

A gas engine directly connected to a 15 kva, 220 volt, 60 cycle, 3 phase generator furnishes power for the truck equipment. In the summer, the air conditioning unit takes in warm outside air through filters and passes it through a set of cooling coils where the air temperature and humidity are reduced, and delivers the conditioned air into the plane through an air hose. The gasoline engine-generator set drives a "Freon-12" compressor through a power take-off and at the same time generates current for operating the blower fan and condenser fan.

For winter operation, the cold outside air passes through filters, then over a hot water coil and through a bank of four electric heaters, where the air is heated to the desired temperature, and then delivered to the plane. Heating of this air is accomplished by circulating hot water from the engine jacket through the hot water coil, and by switching current from the generator to the electric heaters. Individual switches for each of the four electric heaters enable the operator to control the amount of heat supplied to the plane.

Performance of this unit is as follows:

Heating Cycle

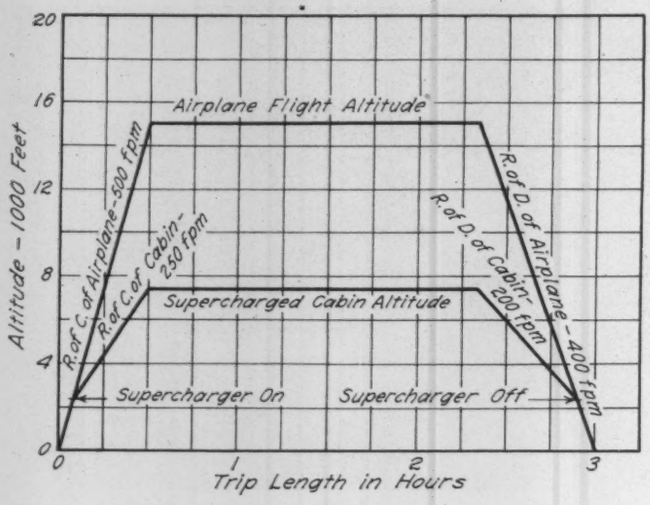
Inlet Air Temperature	0 F
Outlet Air Temperature of Plenum	154 F
Btu per Hr, Electric & Engine Jacket	135,000

Cooling Cycle

Inlet Air Temperature	
Dry Bulb	100 F
Wet Bulb	75 F
Humidity	35%
Delivery Dry Bulb	55 F
Btu per Hr	105,000

Cabin Supercharging

Flight at the higher altitudes gives greater comfort to the passenger, both from the standpoint of smoother flight, as well as permitting closer adherence to schedules. For altitudes up to 10,000 ft the decrease in oxygen pressure (as a result of the decrease in barometric pressure) is not noticeable to the average person. However, above



Comparison of actual flight altitude and supercharged cabin altitude for Douglas DC-4 transport for typical trip length of 3 hr. "R. of C." means "rate of climb" and "R. of D." means "rate of descent"

10,000 ft it may become noticeable and above 15,000 ft may cause distress. The supercharged cabin has been developed to maintain a pressure inside the cabin greater than that outside, thus eliminating the difficulties sometimes experienced with oxygen deprivation. With flights above 15,000 ft, as contemplated with new equipment, the supercharged cabin will be used.

In supercharging an airplane, the cabin is so sealed as to be practically air tight and the air pressure entering the cabin is increased by means of air pumps. The new Douglas DC-4, a four engine, 42 passenger airplane, uses centrifugal pumps driven by two of the airplane's main engines. These pumps run at a constant speed and are capable of maintaining the desired pressure in the cabin at the time that air is being exhausted. By exhausting air in this manner, a constant supply of fresh air for the cabin is maintained. By means of control mechanisms on the cabin exhaust valves, the pressure in the cabin is automatically varied to suit the desired operation.

The superchargers themselves have shown on test to be very efficient at high speed. Therefore, with speed constant it is believed that the temperature rise at the superchargers over that obtained by adiabatic compression should be relatively small. Temperature rise due to adiabatic compression is approximately 3½ F per 1000 ft. This means that at times of supercharging in cold weather, the load on the heating system will be materially reduced. However, for warm weather operation it may increase cabin temperatures above the normal desired range. Because of this, it is planned to use an intercooler in the air system to reduce the cabin temperature to within the desired range.

On the Douglas DC-4, the supercharging equipment is so controlled that apparent altitude in the cabin will be about one-half that of actual flight altitude. A graphical representation of how the control system for the DC-4 operates is shown here.

At the present time, flight altitudes are generally between 9000 and 12,000 ft and oxygen systems as now used by most airlines for supplying O_2 to crew and passengers in unsupercharged cabins are adequate.

FLOW OF SLUDGES

It is generally known that two distinct types of flow can occur when a sludge is caused to flow in a circular pipe. These two types of flow have been termed "laminar" flow and "turbulent" flow, respectively. The flow is said to be laminar when the particles of flowing sludge move in straight lines parallel to the sides of the pipe. The flow is said to be turbulent when the direction and magnitude of the velocity vectors of the flowing particles vary with time.

The relation between head loss and velocity for the turbulent flow of sludge through pipes is not known. The relation has been formulated empirically by some industries using certain types of sludge. For instance, mud is used as a circulating medium in oil well drilling, to hold down gas pressure and bring up the cuttings of the drill bit. Various formulas are in use for estimating the friction loss as this mud flows through the drilling machinery, but these formulas are empirical, derived for a certain mud, and good only for that mud.

It was the purpose of the investigation described in Bulletin No. 323, Turbulent Flow of Sludges in Pipes, by H. E. Babbitt, Professor of Sanitary Engineering, and D. H. Caldwell, Research Assistant in Civil Engineering, which has just been issued by the Engineering Experiment Station of the University of Illinois, to formulate the factors affecting the turbulent flow of sludge and, if possible, to present, for various types of sludge, data which could be used in the design of pipe lines and pumping machinery for conveying various types of sludge.

This work was a continuation of that described in an earlier bulletin, No. 319, which dealt with the laminar flow of sludges.

Until July 15, 1941, or until the supply available for free distribution is exhausted, copies of Bulletin No. 323 may be obtained without charge upon application to the Engineering Experiment Station, Urbana, Ill.

GAS AIR CONDITIONING

The industrial and commercial air conditioning committee of the American Gas Association, 420 Lexington Ave., New York, N. Y., has recently issued its 1940 report. Copies of this 32 p. booklet are available from the AGA at 40 cents each.

The report includes a statement of the committee's thoughts on the subject, and a description of the research projects being sponsored by the AGA jointly with the American Society of Heating and Ventilating Engineers and the National Warm Air Heating and Air Conditioning Association.

The major part of the report is devoted to illustrated discussions of progress made last year by five leading manufacturers of gas using summer air conditioning equipment. The equipment itself is described in some detail, as are the various applications of it.

Converting Ventilating Systems to SUMMER AIR CONDITIONING

G. A. Belsky,* Air Conditioning Engineer, Explains Utilization of Existing Duct Work at Hotel Pierre

INSTALLATION of an air conditioning system for the Corinthian and Oval rooms at the Hotel Pierre, New York City, last year brought to light several of the advantages and disadvantages of utilizing existing duct systems for summer air conditioning.

The first problem to be solved was the design and application of the system with regard to the architectural features of these two beautifully decorated rooms. Care had to be taken so as not to mar the architectural features and yet consideration had to be given to the initial cost of the system. Fortunately an elaborate ventilating system was present and the application was based upon utilizing a great portion if not all of the existing duct work. However, as is the case of all systems that are installed during the actual construction of a building, this ventilating system was quite neatly tucked away. After considerable tracing it was found that the installation of return ducts was impractical as the design was such that it would have been quite costly to redesign and relocate existing air washers and fans.

100 Per Cent Outside Air

It was then decided that 100 per cent outside air would be used in conditioning these two spaces in view of the fact that the cost of the additional capacity required to do the job under these conditions was more than offset by the costly problem of installing return ducts. In addition to the saving of initial cost, the feature of 100 per cent outside air makes it possible for the management to use these rooms for weddings, parties or other occasions that would cause these spaces to become filled to capacity, without the fear of inadequate ventilation. In addition, it makes it possible for the engineers to operate this ventilating system in the same manner that they had been accustomed to since the ventilating system was installed.

SUMMARY—In Mr. Belsky's opinion, best practice when converting existing ventilating systems to summer air conditioning is to leave them as they are — insofar as is possible—so that the result they were originally designed to achieve will not be affected in any way after the cooling season is over. This principle was applied in the installation of air conditioning for two rooms at the Hotel Pierre in New York City. . . . It was decided to use 100 per cent outside air, as it was found that the cost of installing return ducts would more than offset the cost of the additional capacity required; the 100 per cent outside air feature also removes any danger of inadequate ventilation when the rooms are used for special functions and are crowded to capacity. The existing supply openings, at a height of 6 ft from the floor, with directional flow grilles, were used; smoke tests have shown the air distribution to be quite satisfactory. . . . Three 20 hp machines are situated in an equipment space which was formerly a locker room, and the outdoor type evaporative condensers are on the same level on the roof of the court. Vibration and machine noise was cared for by using vibration eliminator rails, and by 1 in. of board insulation on the walls and ceiling

This in itself is an asset, because when present ventilating systems are revamped for the purpose of installing air conditioning, the usual result is that the ventilating effect experienced for years is upset after the cooling season is ended.

Air Distribution

The spaces served have areas of 4261 and 1354 sq ft, respectively, and the volumes are 118,000 and 34,000 cu ft. Due to the high ceilings it was decided to use the existing supply grilles which were situated in the window jambs at a height of 6 ft from the finished floor, disregarding the opinion that this would not be productive of good air distribution. Directional flow grilles were installed at all of these openings on three sides of the Corinthian room, and the air is introduced at an angle of 20 deg to the vertical surface. Now that the job is installed and operating, smoke tests show that in the vicinity of the supply grilles all of the air movement in evidence is negative or secondary and the air distribution is entirely satisfactory. This should go a long way to prove that cold air can be diffused at low levels without objectionable draft or air motion to people seated in these areas. The maximum diffusion temperature difference maintained at the register is 15 F.

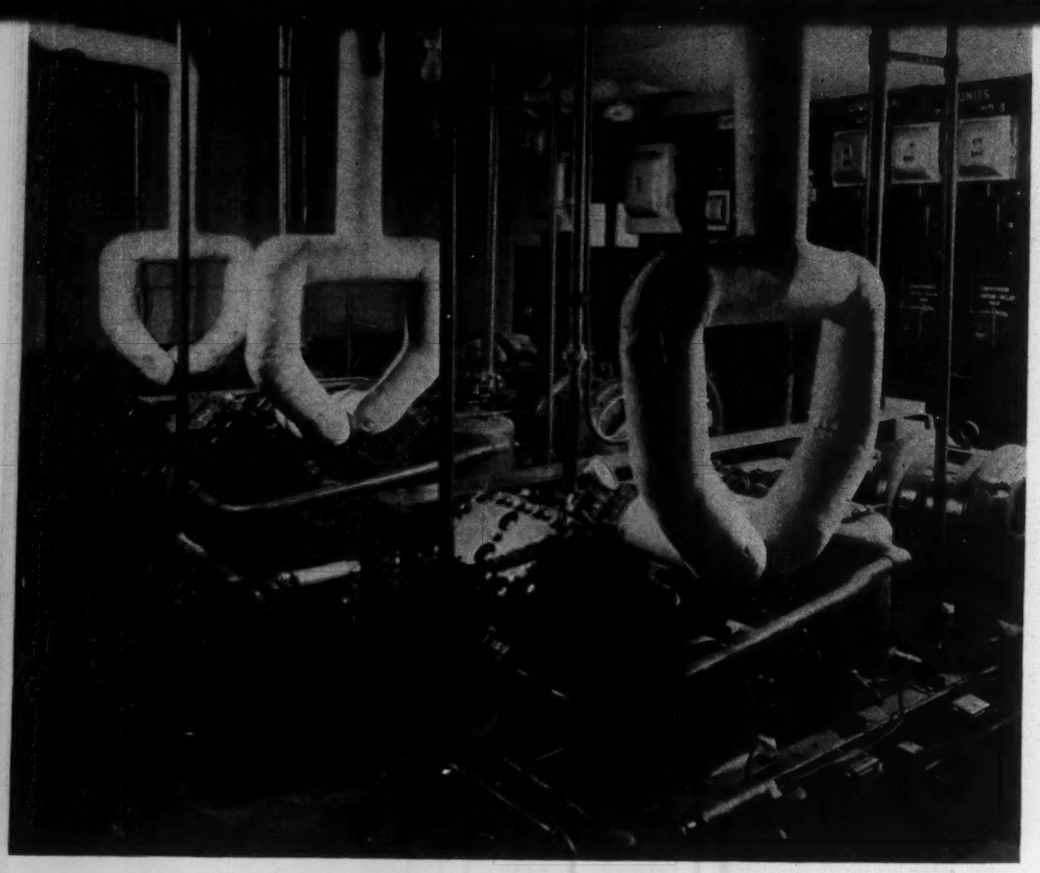
The air distribution in the Oval room was accomplished by installing a new branch supply duct and connecting it to an existing exhaust duct in the ceiling at the center of the room. Dampers were used so as to make it possible to use this duct for its primary duty of exhaust during the winter season. The existing plaque is used to diffuse this air that is introduced at the ceiling. This method of introducing air into the Oval room was quite obvious and produces good results.

Insulation

All of the supply duct work, as well as the plenum chamber in which the cooling coils are housed, and the supply fan, were insulated with 1 in. of cork and the supply ducts at the window jambs were insulated by blowing rock wool down their sides.

Sixty tons of refrigeration equipment was installed to serve these two spaces. The equipment was subdivided into three 20 hp machines, and the direct expansion coils in the existing plenum chamber are arranged so that each ma-

*Chief Engineer, Justin C. O'Brien Co., Inc.



Three 20 hp refrigeration machines serve the Corinthian and Oval rooms at the Hotel Pierre, New York City. One of the locker rooms was used as the machine room. Starting and control equipment, switches, etc., are mounted on a good looking panel board. The problems of sound and vibration were solved by using vibration eliminator rails for the machines, and 1 in. of insulation on walls and ceiling of machine room

chine and each coil has individual liquid and suction lines. Evaporative condensers are on the same level as the machines and coils and are on the roof of the court; this eliminated the installing of excessive duct work for the purpose of supplying and discharging the air needed for evaporating purposes.

It is interesting to note that, at the insistence of the purchaser, it was planned to put the condensing units on the roof with the evaporative condensers, making it necessary to install heavy steel and housings so as to support and protect this equipment. During the course of the installation it became quite obvious that a good size penthouse was necessary and the management was doubtful as to whether or not it would be unsightly. It was therefore proposed by the contractor that another location be found for the condensing units. One of the locker rooms on the same floor was surrendered for this purpose. This change necessitated quite a bit of additional refrigerant piping. However, this cost was balanced by the saving due to lighter steel construction and the elimination of the penthouse which now became unnecessary because the evaporative condensers are of the outdoor type. The three machines were placed in the space mentioned and set upon vibration eliminator rails. It also became possible to erect a good looking panel board in this new equipment room and mount all the starting equipment, control equipment and switches thereon. This would not have been practical had all of the equipment been placed on the roof.

Vibration and Noise

When the job was placed in operation it was found that considerable vibration as well as machine noise was being transmitted out of the equipment room. This problem was solved by the installation of 1 in. insulation board placed on furring strips on all four walls of the room and ceiling. The floor loading as well as location of steel members were rechecked and the vibration eliminator rails were redesigned for each individual machine. The combined effect of this sound and vibration elimination was remarkable and the machines now cannot be heard for more than a distance of a few feet from the room.

The system as installed has quite a factor of safety as far as capacity is concerned and only at rare occasions do the three machines operate simultaneously. At such times as this the equipment room becomes quite hot and because of the abundance of capacity a cold air supply duct was run to this machine room so as to prevent the heater elements in the starters from overloading.

At the time that this installation was made the Cafe Pierre was being constructed in the hotel and the air conditioning contract for this space was let at the same time. This installation could be made during the time when the cafe was being constructed and it was possible to fit the duct system to the architectural design. There were several limitations as to size of duct work because of the peculiar shape of the room, which is 100 ft long, 15 ft wide and 9 ft high. It was therefore necessary to rise with supply duct work at four separate spaces so that the size of the duct work was kept at a minimum throughout the room. The 15 hp refrigeration equipment was installed in the basement under the cafe.

It has been the writer's experience that when utilizing existing ventilating systems for summer air conditioning, the best practice is to leave them as they are as far as it is possible, so that the result that they were installed to produce originally is not affected in any way after the cooling season is over.

Contented Cows—A modern air conditioned dairy accommodating 120 cows has been built on the Malayan Peninsula, based on findings from small-scale experiments covering four years. The cows now live in a milder climate than cows on the isle of Guernsey, in spite of the fact that the outdoor thermometer often registers 100 F and humidity is almost unbearable. Temperature in the barn is maintained at about 75 F at all times.

Dairy experts in Singapore discovered that abnormally high temperatures and excessive humidities were reducing daily milk production and shortening the period of lactation. Four years ago, a specially-designed air conditioning system was installed in a small barn housing 17 of the Singapore Dairy Farm's best Holstein cows. In the air conditioned barn, cows have yielded as high as 60 lb of milk per day. The air conditioning does not increase milk production, but does prevent production from being prematurely reduced by hot weather.

Heating · Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

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Comfort and Health and Temperature a Mathematical Solution

By W. L. Fleisher* and W. L. Fleisher, Jr.**

New York, N. Y.

COMFORT and temperature have been so closely associated from time immemorial, that there seems no escape from the fact that there is a close relationship between them. Humidity, too, has always been correlated with this same temperature and undoubtedly plays a major part in the feeling of comfort.

The adjustment of man to his environment, the maintenance of an equilibrium temperature, his departure from a normal temperature in times of sickness and disease, his efficiency, his irritability in response to the weather or at times of storm, all point to a fundamental relationship between man and his environment. It is a fascinating problem and the purpose of this paper is to try to offer a solution.

As temperature is the basis of this discussion it is proper to start with a definition of temperature as related to heat as recognized by the physicists. They define the thermodynamics of temperature, as enunciated in Haas' *Introduction to Theoretical Physics,* as follows:

"In every case in which energy is distributed among a very large number of individuals in a manner not directly perceptible to human senses, this energy may be interpreted as heat. This heat energy, when distributed throughout bodies, is identified with molecules. All quantities which, in a statistical sense, are proportional to the number of individuals must, therefore, in a thermal sense, be proportional to the number of molecules or to the mass. From the electron theory that the forces acting between the particles of matter are central forces depending only upon the distance between the particles, a system of this kind is governed by the Principle of the Conservation of Energy. If the internal forces only depend on the distances separating the individual molecules, then the internal energy will evidently depend only on one parameter, viz., on the volume of the unit of mass, or the so-called specific volume."

Haas goes on to show that in a perfect gas, if a system of molecules is considered, the energy of which may be regarded as purely kinetic, the theorem of equipartition leads to the two relations

$$E = \frac{s}{2} NkT \quad \ldots\ldots\ldots\ldots (1)$$

and

$$pV = NkT \quad \ldots\ldots\ldots\ldots (2)$$

In these equations N denotes the number of molecules, k Boltzmann's constant, and s the number of degrees of freedom of the molecules. From Equation (2) an important conclusion can be derived, to the effect that at equal pressure and equal temperature equal volumes of gases must contain the same number of molecules, and that at given pressure and given temperature the volumes of different gases are in the ratios of their molecular weights.

In a further development of this formula, it will be noted that

$$pV = NRT \quad \ldots\ldots\ldots\ldots (3)$$

Since the energy of a homogeneous body must, in general, be determined by volume and temperature, it follows that the derivative of

$$\left(\frac{\partial E}{\partial V}\right) = 0.$$

From this formula can be calculated approximately the dependence of the vapor pressure on the temperature and that degrees of temperature represent intensities, not quantities, of heat.

As previously indicated, this paper will deal with two rather abstract qualities, comfort and temperature, and as temperature translated from its heat source seems to affect individuals through the surrounding air, it is logical to analyze the properties of an air-water vapor mixture from a thermodynamic angle.

Before beginning this analysis it is desirable to emphasize the reason for the investigation by relating the theory to the comfort and health of human beings. In studying what conditions of the atmosphere or what ambient conditions in enclosures produced comfort or discomfort, physiological changes or dislocations, the authors studied the literature on the subject found in the TRANSACTIONS of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, dating back over a period of 20 years. Starting with the reactions of human beings to high temperatures and high humidities, Society researchers turned to normal temperatures and varying humidities. The TRANSACTIONS of the Society from 1923 to 1939 have numerous technical papers each year on this research problem. In 1938 and 1939 the Committee on Research of the Society renewed its investigations on the reactions of workers in industry to imposed conditions of the surrounding air.

Out of this research was developed a zone of comfort for winter and summer and a series of effective temperature (ET) lines. This work represents an outstanding contribution of the Society to scientific research.

An explanation of the effective temperature lines is essential to the understanding of the development outlined herewith. THE GUIDE 1940 of the Society defines effective temperature: ". . . an arbitrary index which combines into a single value the effect of temperature, humidity and movement of air on the degree of warmth or cold felt by the human body". To be more specific, a psychrometric chart is shown in Fig. 1 giving effective temperature lines for persons normally clothed and slightly active, as developed over many years by the ASHVE Research Laboratory,

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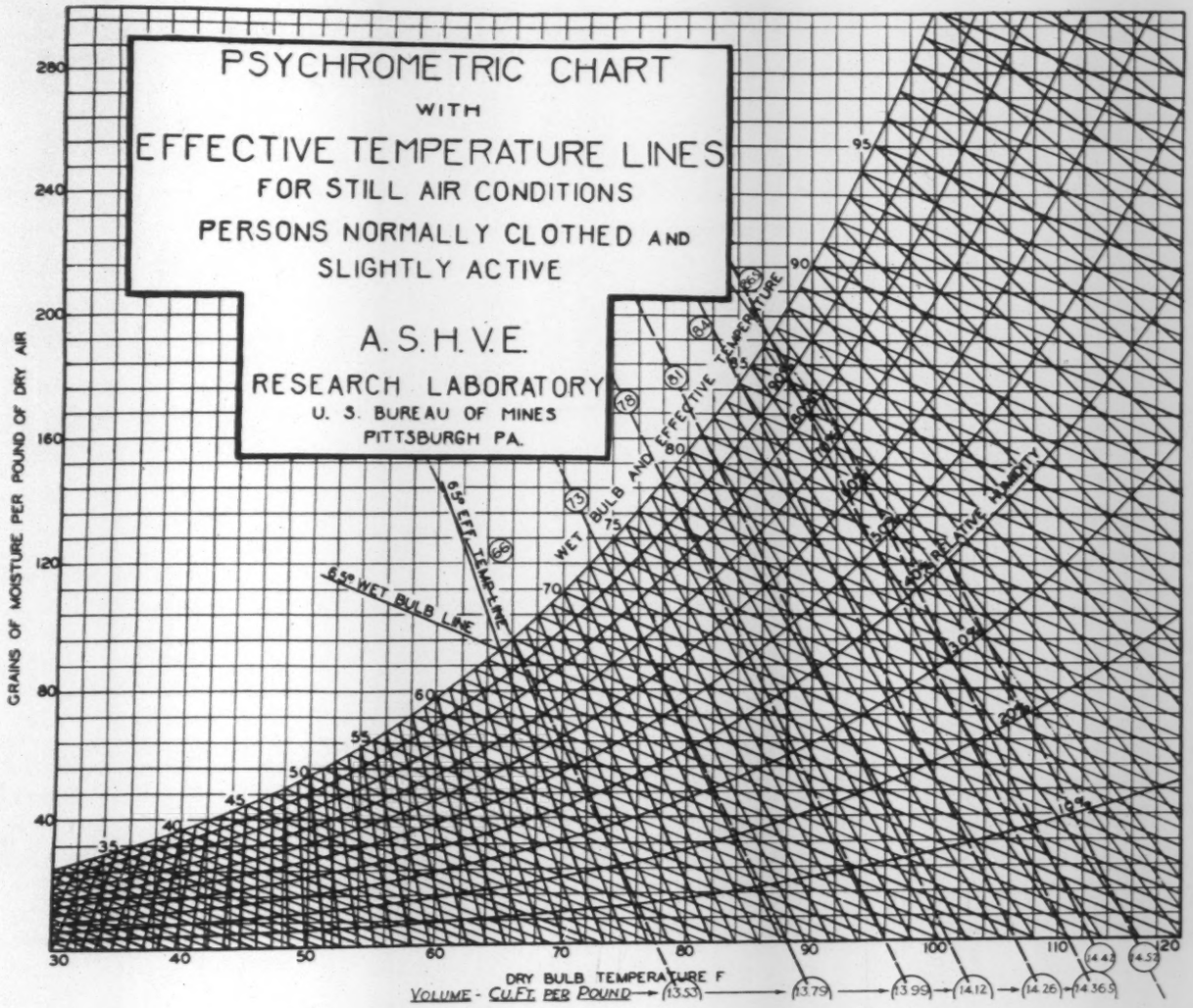

Fig. 1—Psychrometric chart with effective temperature and constant volume lines

Pittsburgh, Pa. Design conditions for most cooling installations in the summertime indicate that a 73 deg ET, which varies over a wide range of relative humidities, is the most satisfactory for most people. Given in Table 1 are the temperature and moisture conditions for extreme points of relative humidity on the 73 deg ET line—that is, high and low, which show that at 70 per cent relative humidity there is a dry-bulb temperature of 76.1 F, a wet-bulb temperature of 68.9 F, a dew-point temperature of 65.6 F and 95 gr (grains) of moisture per pound of dry air. At 50 per cent on the same line, there is a dry-bulb of 78.8 F, a wet-bulb of 65.7 F, a dew-point of 58.6 F and 74 gr of moisture per pound of dry air. At 30 per cent on the same line, there is a dry-bulb of 81.7 F, a wet-bulb of 61.7 F, a dew-point of 47.5 F and 49 gr of moisture per pound of dry air. If total heat, as represented by the wet-bulb, is the measure of comfort, how is it that on this effective temperature line variations exist from 68.9 F wet-bulb to 61.7 F wet-bulb, or total heats of 33.9 Btu per pound and 27.5 Btu per pound of dry air with vapor to saturate it.

In further investigations[1] of the reactions of human beings, the Research Laboratory of the Society and its co-operating groups discovered that at 86.5 deg ET a marked physiological change took place in all of the persons subjected to this condition. An examination of the variables on this effective temperature line show in Table 1 that at 70 per cent relative humidity, the dry-bulb is 92.2 F, the wet-bulb is 83.8 F, the dew-point 81.1 F and 163 gr of moisture per pound of dry air. At 50 per cent relative humidity the dry-bulb is 97.2 F, the wet-bulb 81 F, the dew-point 75.5 F and 134 gr of moisture per pound of dry air. At 30 per cent relative humidity the dry-bulb is 103.8 F, the wet-bulb 77.3 F, the dew-point 66 F and 96 gr of moisture per pound of dry air and a corresponding difference in the total heats. It would seem that there was no relationship whatsoever in these different points, but how to account for the fact that human beings have reactions almost exactly alike as to comfort, when comfortable, or physiological changes when such changes take place at each of these combinations, is a subject worthy of investigation, if the many tests that had been made on human reactions or physiological changes were sound. The common factor of comfort at these different conditions or the common factor of marked physiological change and discomfort at such seemingly dissimilar conditions were too evident

[1]ASHVE Research Report No. 1106—Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber (ASHVE TRANSACTIONS, Vol. 45, 1939, p. 59).

Table 1—Tabulation of Psychrometric Conditions Corresponding to Various Effective Temperatures

Effective Temp. Deg ET	Relative Humidity Per Cent	Temperature Deg Fahr. Dry-Bulb	Wet-Bulb	Dew-Point	Grains per Pound	Specific Volume Cu Ft–Lb (Dry Air Plus Water Vapor)	Specific Volume Corres. to ET at Saturation
73	70	76.1	68.9	65.6	95	13.79	13.79
	50	78.8	65.7	58.6	74	13.79	13.79
	30	81.7	61.7	47.5	49	13.79	13.79
78	70	82.1	74.3	71.1	116	14.01	13.99
	50	85.6	71.1	65.0	94	14.03	13.99
	30	89.6	66.8	54.0	62	14.04	13.99
86.5	70	92.2	83.8	81.1	163	14.42	14.365
	50	97.2	81.0	75.5	134	14.47	14.365
	30	103.8	77.3	66.0	96	14.52	14.365

to be merely experimental, empirical or simply chance. What was there at these various points on an effective temperature line that was similar and that would give a clue to the markedly similar reactions of human beings at these diverse conditions? Strangely enough and strange only because it appears that it has not previously been noted, all points on an effective temperature line from 100 per cent relative humidity to zero per cent relative humidity *are on a constant specific volume line.*

Referring to the psychrometric chart of effective temperatures in Fig. 1 for lines of 73 deg ET, the specific volume is 13.79 cu ft per pound for all points from 0 per cent relative humidity to 100 per cent relative humidity. This same relationship holds true for any other effective temperature line. In other words, as long as the absolute pressure remains constant people react exactly the same to the same specific volume (by specific volume is meant the cubic feet occupied by a pound of dry air and its moisture or water vapor).

Where the effective temperature line deviates from a constant specific volume line it is felt that the effective temperature line is in error because the evidence is all in favor of the theory that these points all lie on a constant specific volume line.

Next consider the 86.5 deg ET line where a strange reaction takes place physiologically. The theory shows that this effective temperature line lies or should lie on a specific volume line of 14.365. Actually, the effective temperature line as developed by the Society varies from 14.42 at 70 per cent relative humidity to 14.52 at 30 per cent relative humidity. As the physiological tests at this line were indicated as uncomfortable by all the subjects, there was only one way to develop this line empirically, and that was by exactly similar physiological reactions. If new tests are conducted on this theory, it is believed that a much closer relationship to a constant specific volume line would be found to exist. It is apparent that a definite physiological change had taken place in every one of the individuals subjected to these conditions.

Next consider a critical effective temperature line, that is, the 78 deg ET line. Here, according to the records of recent tests[2], physiological changes started which correspond to a specific volume of 13.99 cu ft. This compares with a dry-bulb temperature of 78 F at 100 per cent relative humidity and 96 F at 0 per cent relative humidity. Special attention should be given to the dry-bulb temperature at 0 per cent relative humidity. As soon as the specific volume line at 0 per cent relative humidity corresponds to the blood temperature, the entire physiological reaction of the body changes. It probably is easier to determine when a change takes place by projecting the specific volume line to the 0 per cent relative humidity line than by any physical means. Above the 78 deg ET line, or rather the 13.99 specific volume line, it will be found that the body no longer can establish a simple balance, and other factors are introduced to compensate. Charts from previous tests[3] shown in Figs. 2, 3 and 4 indicate that at 77.5 deg ET a rise in body temperature, a feeling of warmth and body perspiration take place, all indicating the *beginning* of a physiological change.

By taking the statistical results of field tests[4] made over a two-year period with 274 subjects, it will be noted in Fig. 5 that over 75 per cent of all subjects are comfortable at about 70 deg ET and that although about 40 per cent are comfortable at 75 deg ET, none are comfortable over 77.5 deg ET.

The specific volume theory is not to be construed as the underlying disclosure of this paper indicating expected reactions from an effective temperature scale. However, the closeness of the location of the constant specific volume lines to the effective temperature lines was the clue to the basic discovery.

The theory of the kinetic energy of gases is the basis of the mathematical theory developed in this paper. Heat is a form of energy—or probably the kinetic energy of confused oscillating motions of the particles of matter. It is necessary

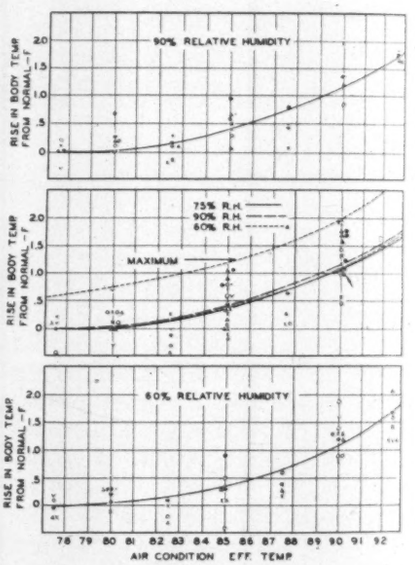
90% RELATIVE HUMIDITY
RISE IN BODY TEMP FROM NORMAL—F
75% R.H.
90% R.H.
60% R.H.
MAXIMUM
60% RELATIVE HUMIDITY
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92
AIR CONDITION EFF. TEMP

Fig. 2—Relation between rise in body temperature from normal during three hours exposure and effective temperature of the air condition in test room for 60, 75 and 90 per cent relative humidities. Test points for individual subjects apply to heavy solid curves

to determine the part specific volume contributes in the energy formula for gases.

It has already been indicated that

2, 3 Loc. Cit. Note 1.

[4] ASHVE Research Report No. 1088—Summer Cooling Requirements of 275 Workers in an Air Conditioned Office, by A. B. Newton, F. C. Houghten, Carl Gutberlet and R. W. Qualley (ASHVE Transactions, Vol. 44, 1938, p. 337).

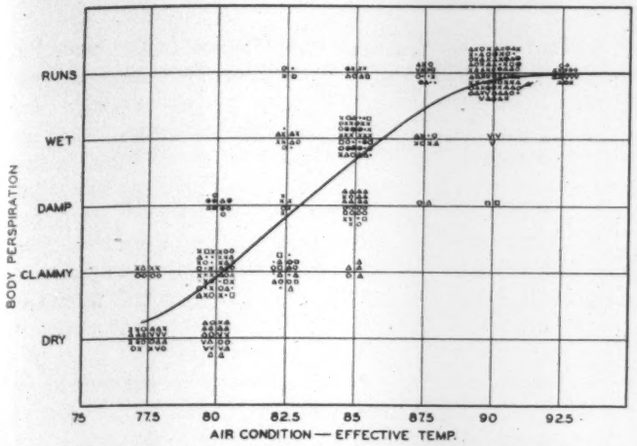

Fig. 3—Relation between degree of perspiration on body after three hours exposure and effective temperature of air in test room. For all subjects in tests at 60, 75 and 90 per cent relative humidity

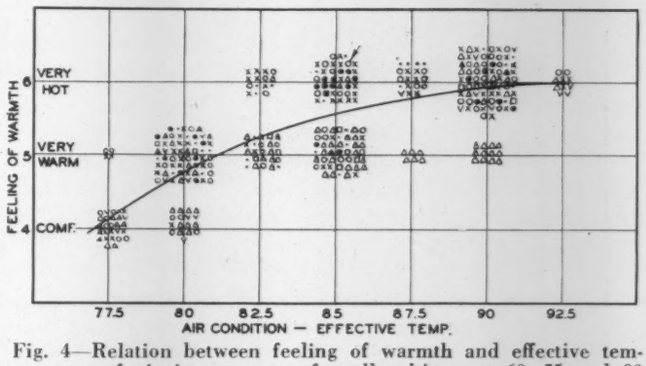

Fig. 4—Relation between feeling of warmth and effective temperature of air in test room for all subjects at 60, 75 and 90 per cent relative humidity

the pressure exerted by any perfect gas is a function of the number of molecules per unit of volume, the mass of the molecules of the particular gas considered and the mean of the square of the velocity of the molecule. This can be developed, as very simply expressed by Hausmann and Slack in their *Kinetic Theory of Gases* into the formulae which follow.

It is known that energy is needed to raise the temperature of a substance, and thus the temperature of a gas is assumed to be directly proportional to the kinetic energy of the gas molecules. The intermediate velocity v must, therefore, be such as to impart the same kinetic energy to N molecules, each of mass m, as that due to their individual velocities, v_1, v_2, . . . v_N Hence,

$$N\ (\tfrac{1}{2}m\ v^2) = \tfrac{1}{2}\ m\ v_1^2 + \tfrac{1}{2}\ m\ v_2^2 + \ldots \tfrac{1}{2}\ m\ v_N^2 \ldots . (4)$$

The varying individual velocities may therefore be replaced by a single velocity which is found by squaring the individual velocities, taking the mean of these squares, and then extracting the square root. The result is known as the root-mean-square or *rms* velocity.

Consider a cubical box of volume $V = l^3$, containing N molecules of gas each of mass m, and let the rms velocity of the gas molecules be v. The actual motions of the molecules within the box can be resolved into three components, as though one-third of the molecules were moving perpendicularly between each pair of opposite faces. Such a group of molecules moving between face A and that opposite would encounter many collisions on the way. Suppose the collisions to occur after traveling a small uniform distance x from A. The number of molecules in a zone of this thickness would be $\frac{x}{l} N$, one-third of which would strike A with a velocity v and rebound with a velocity of $-v$. Each of these molecules thus undergoes a change of momentum of $2\ m\ v$, which is accordingly equal to the impulse imparted to the wall by collision. Including all of the molecules striking face A, the impulse per impact is

$$Ft = \tfrac{1}{3} \times \frac{x}{l} N \times 2\ m\ v \ldots (5)$$

The molecules travel $2x$ in a time $\frac{2x}{v}$ and strike $\frac{v}{2x}$ times per second. Total impulse per second is therefore = to F, and

$$F = \frac{x\,N}{3\,l} \times 2\ mv \times \frac{v}{2\,x}$$

by factoring, therefore

$$F = \frac{Nmv^2}{3\,l}$$

and the pressure on the face

$$= P = \frac{F}{l^2} = \frac{N\,m\,v^2}{3\,l^3} = \frac{N\,m\,v^2}{3\,V}$$

or

$$PV = \frac{N\,m\,v^2}{3} \ldots\ldots\ldots\ldots (6)$$

The kinetic theory of gases can be expanded for a mixture of gases such as air and water vapor by the use of Dalton's law of partial pressures.

$P = P_1 + P_2 + P_3$, etc. . . . . (7)

or the total pressure equals the sum of the partial pressures in a gas mixture.

The pressure of the air surrounding human beings $= P_1 = \frac{1}{3}(N_1 m_1 v^2)$ and the pressure of the water vapor $=$

$$P_2 = \frac{1}{3}\ (N_2 m_2 v_2^2)$$

Therefore, substituting in Equation (7) the values of P_1, P_2, etc.

$$P = \frac{1}{3}\ (N_1 m_1 v_1^2 + N_2 m_2 v_2^2, \text{ etc.}) \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

and

$$P\ \frac{V}{w} = \frac{1}{3}\ \frac{V}{w}\ (N_1 m_1 v_1^2 + N_2 m_2 v_2^2) \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

This gives the specific energy of the gas mixture which is bombarding the human body. At constant barometric pressure P and constant specific volume $\frac{V}{w}$ the total specific kinetic energy is constant, regardless of the molecular composition of the mixture.

Equation (9) does not give the complete analysis. While it interprets physiological reactions in terms of basic kinetic energy, it does not explain it in terms of temperature. Curves shown in Fig. 6 give the relation between the mean velocity of the various component gases and the sensible temperature. It will be noted that for any temperature t the quantity $m\ v^2 =$ a constant. From Fig. 6 at 68 F air has a molecular weight of 28.97 and at this temperature 68 F a mean velocity of 4.62 $cm \times 10^4$ per second. At this temperature $m\ v^2$ of air equals $m_1 v_1^2$ of water vapor at the same temperature[5], or $H_2O = 18 \times (5.87)^2$ and air should equal $28.97 \times (4.62)^2$. Actually the readings are slightly incor-

[5]The values of 5.87 and 4.62 are constants of the kinetic theory of gases.

rect, but are close enough to illustrate the theory. For any air-water vapor mixture, the air and water vapor are at the same temperature so that all the molecules in the mixture have the same kinetic energy. This means that any mixture, from the purely kinetic energy viewpoint, can be considered as a single gas, and the equivalent temperature point is at zero per cent relative humidity. Therefore, since the body reacts to the atmosphere purely on an energy basis, the equivalent temperature at 0 per cent relative humidity is the temperature or energy to which the body responds. This can be shown mathematically:

$v = f(t)$ (when v is the mean velocity of the molecule) (See Fig. 6). ..... (10)

and $m_1 v_1^2 = m_2 v_2^2 = C$ at the same temperature..... (11)

If Equation (9) is solved in terms of Equation (11),

$$P \frac{V}{w} = \frac{1}{3} \frac{V}{w} m_1 v_1^2 (N_1 + N_2)$$

..... (12)

and substituting Equation (10) in Equation (12),

$$P \frac{V}{w} = \frac{1}{3} \frac{V}{w} m_1 [f(t)]^2 (N_1 + N_2)$$ ..... (13)

Equation (13) places the energy equation in terms of a single gas and its corresponding temperature, that is, at 0 per cent relative humidity where no water vapor exists.

An infinite number of relationships can be developed between air and water vapor and the energy of bombardment per unit volume, where specific volume and pressure remain constant will still have the same specific kinetic energy. In other words, the moisture content in a pound of air can vary from 0 to 100 per cent saturation without changing its kinetic energy bombardment, as long as the barometric pressure and the specific volume remain constant. The effect of an air and water vapor mixture under constant barometric pressure can be foretold by determining the specific volume of the mixture. It will be seen from this deduction, for instance, that with lower barometric pressure greater specific volume will be required to balance the equation or at great heights more heat is required to obtain the same energy. In deep mines, lower specific volumes are required for the same balance.

It was previously mentioned that the 78 deg ET line, at which line physiological changes in the human body begin, crosses the 0 per cent relative humidity line at about 96 F. The kinetic energy given out by the body corresponds to an energy represented by a heat level of 96 to 98 F. The protective level of the body against its environment is therefore positive up to an energy level from without, represented by the mathematical equivalent of the energy of the air and water vapor part of the equation under constant barometric pressure of 29.92 in. of mercury corresponding to the numerical value of 13.99 cu ft per pound of dry air and its water vapor. When the kinetic energy exceeds that equivalent, the temperature of the body rises to ward off the introduction of too much energy or the absorption of too many energizing units (corpuscular theory of bombardment). The determination of the wave lengths creating these conditions is under consideration for further investigation.

If this theory is applied to the reactions of human beings and the limiting conditions of comfort are taken from the ASHVE comfort chart, *no one* at rest in winter feels comfortable below 66 deg ET. This from Equation (13) occurs at a temperature of 77.5 F and 0 per cent relative humidity, and no one under the same conditions of rest feels comfortable over 79 deg ET, almost exactly equivalent to 98 deg at 0 per cent relative humidity (the reason for the 77.5 F equivalent relationship is not brought out in this paper).

The theory is further confirmed by the fact that premature babies require an 85 F dry-bulb temperature and 65 per cent condition in order to complete their development. It will be noted from the mathematical development in this paper that this corresponds to a bombardment equivalent to 98.6 F on the 0 per cent relative humidity line.

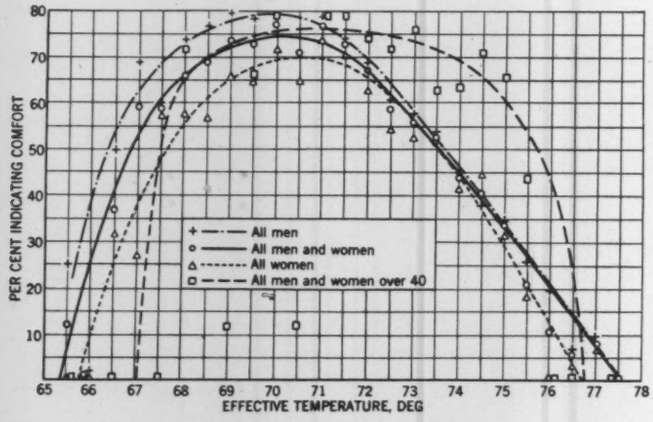

Fig. 5—Relation between effective temperature maintained in conditioned space and percentage of observations indicating comfort for period August 2 to September 3, 1937. Curve for all men and women under 40 coincides with curve for all men and women

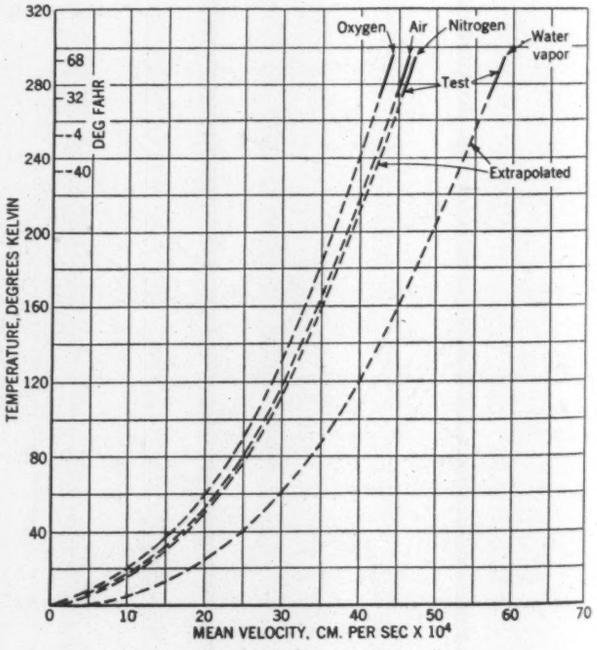

Fig. 6—Mean velocity curves for kinetic energy equation for air and its components

There may be some criticism of the basic theory in that at higher air movements, the adjustment to imposed conditions appears to be at a higher effective temperature. This can be explained by the theory that the primary adjustment is through a vapor film and an air film, and that when a high wiping effect is achieved by the movement of a moving film over a stationary film, the molecular pattern is changed and a greater number of heat or energy waves can penetrate from the higher to the lower environment.

The theory has its greatest value in that it orients feelings of comfort, or physical reactions to the surrounding air, in terms of physical law and a mathematical equation relating comfort to the physical matter or molecules which constitute the atmosphere. Effective temperatures have been purely empirical up to this time. The kinetic energy theory definitely establishes the validity of the observations along the effective temperature lines and beyond everything else establishes a method of investigating the physiological processes involved in the life processes.

THE POTENTIAL REASONS FOR THE PRE-EMINENT POSITION OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is potentially the most important humanitarian organization in the world.

That, of course, is a controversial statement, that must be defended with facts, philosophies and determination.

In its early years, the Society suffered under the inferiority complex of being a pipe fitting organization. The members themselves, as well as the public generally, had forgotten that heating and ventilating was originally the work of the physician. It was the advent of modern air conditioning, however, with its glamorous potentialities that eventually saved the heating and ventilating engineer and restored his ego.

Air conditioning brought about a revival of intensive research to discover the reasons underlying the so-called physiological reactions to unusual conditions of the surrounding air.

With this revival of research, we became scientists, and as scientists we resumed our position among the learned professions. Really, heating and ventilating were always a profoundly scientific study and based on thermodynamics the theory was, and is, almost too difficult for the average engineer to comprehend. To conceal his ignorance, he, therefore, followed empirical rules, like the doctor; or rules of precedence, like the lawyer; or rules of faith or dogma, like the preacher.

But where the doctor or the lawyer prescribe for the sick—fortunately, only a small percentage of the people—the air conditioning engineer, for under that term I embrace everything having to do with the control of air, prescribes for both the well and the sick, or for 100% of the population. His influence, therefore, is vastly greater than that of any of these learned groups, although the public does not necessarily recognize it.

We have become so accustomed to the good things of earth, that we pay little attention to them until we have to do without them. The old stories of the choice between gold and silver or salt, and diamonds and pearls or sunlight, are two of the innumerable fables bearing on this point.

With the recognition of our power, gained by scientific research and deep analysis and reasoning, to adjust our surroundings to our physical requirements, we became, possibly unconsciously, the greatest "physicians" of all times, certainly with a vastly greater patronage than that enjoyed by any other group interested or occupied with a humanitarian purpose. We could take the invisible air and the still less comprehended molecules of water vapor and combine them into an invisible combination, that would bring delight or distress at will, and we could call in the psychologist to interpret, and then make his interpretations seem ridiculous simply by turning on or off a little steam or a small quantity of cold water. And if we had followed our research with comprehension, we could tell why we had accomplished a miracle or could predict the results in advance.

We could control, produce or relieve disease. We could accelerate or retard both mental and physical work. We could make it possible for the surgeon to perform his skillful feats, or make him bungle the performance; the lawyer to think straight (if that is possible) and the minister to hold his congregation together. We could make goods function in the machines, or make wood ready for the cabinet maker. We not only are masters of man's fate, but controllers, too, of his necessities.

Lately, we have learned that we are dealing with the very fundamentals of existence. Time and space and gravity, the theory of the electron, the equations of relativity, the periodicity of the elements, are no more basic than the fundamentals of the science of which we are a part. Our potential greatness lies in developing still further the beginning we have made in an understanding of these things. As we deal with a greater number of people and with more things than any other profession, we must be more careful and more thorough than any other in our approach. If admission to our ranks and our Society is a pass-word to that greater knowledge, there should be no honor greater than qualification for admission to our Society.

And so I say, rather than inferiority we should carefully avoid the arrogance that membership in our Society might rightfully encourage.

With this understanding we should approach all those capable of appreciating our aims and our potentialities, and by bringing into our group those great minds who believe in our principles and our endeavors, make the Society the greatest boon to humanity of any scientific organization now in being.

President, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The Influence of Physiological Research on Comfort Requirements

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This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in cooperation with the University of Illinois, College of Medicine.

MEMBERS of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS have proposed to the public that they can furnish a controlled atmosphere, which is preferable to the uncontrolled one supplied by nature. This proposal sets up a thesis with two major premises, and shoulders the responsibility for their proof upon the Society. In the first place the atmospheric environment must demonstrate its value by bringing more comfort to its subjects than an uncontrolled one. If it does this, people will spend money to secure it. In the second place, it must be so selected and so secured that harm will not result to the subjects. Both of these premises were early recognized by the Society and investigative work was undertaken to define the comforts and dangers of conditioned air.

For the purposes of discussion of the problems involved, a crude but simple analogy may be adopted. If an incubator, which has varying quantities of heat liberated within it, is furnished with a delicately operating thermostat, its temperature should be maintained at a relatively constant level. If this incubator is now placed within a room whose temperature is controlled within 3 to 4 F—the maintenance of a constant temperature will prove easy. If it is placed out of doors the task will become exceedingly difficult.

The Varying Heat Production

The transformations of energy within living cells as measured by heat production are dependent largely on the temperature of the cells. In certain animals (lizards, frogs, the so-called poikilothermous animals) a mechanism for the maintenance of a constant temperature is absent or poorly developed. When the surroundings are cold, the rate of heat production falls, activity slows, and at times apparently ceases. The animal suspends animation and hibernates. When the sun shines again and warms up the cells, oxidations speed up and activity appears. The transformations are governed almost entirely by the environmental temperature. Work can be accomplished only when the temperature reaches an optimal level permitting the cells to draw upon stored sources of energy. Once this energy is converted there is no mechanism for the conservation of the extra heat developed.

In man a heat regulating mechanism for the maintenance of a constant temperature of 98.6 F has been developed. Any departure of the temperature from this point interferes with the energy transformations. The cells cease to function and the individual becomes seriously crippled or dies. The upper endurable limit of temperature over a limited period of time is found around 106 F. The lower limits have been extended somewhat, recently, by the refrigeration experiments of Temple Fay.[1] In health the body temperature remains surprisingly constant through all varieties of environmental temperatures and this has extended the functional capacity of the biological machine in man to 12 months out of the year. A constant supply of energy is required to maintain this temperature level of the body and to keep it in a state of preparedness for work. This exchange is spoken of as the basal metabolism and its magnitude is dependent on the sex, age and surface area of the individual. The heat production takes place in all the active cells. Loewy[2] estimates that the heart action accounts for about 3.6 per cent, and the respiratory movements for 10 per cent. Krogh[3] places the kidney requirements at 5 per cent, and those for the functional activities of various organs at 25 per cent. This leaves 75 per cent of the heat to be produced by oxidations in the tissues apparently at rest. The muscles represent more than half of the total weight of the soft tissues of the body and it is in these that the great bulk of the heat is developed. This is substantiated by the rapid fall in the heat production which follows the isolation of the muscles from the nerves with a drug (curare) or by large doses of anaesthetics. This basal energy exchange may be reduced by 40 per cent if the individual is deprived of his thyroid gland and by 20 per cent if the adrenal glands are damaged. This leaves a residual heat production which would have to be attributed to the temperature at which the cells were maintained.

If an individual is given food the heat production is increased approximately 10 per cent. If he is required to do work, it may be increased 500 per cent or more. The mechanical efficiency of the body is usually placed at 20 per cent, so that the heat required for a small amount of work is large. One may now visualize the daily heat production as a phasic process. In the early morning hours the machine is idling and the heat production is at

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[1]Temperature Factors in Cancer and Embryonal Cell Growth, by L. W. Smith and T. Fay (*Journal American Medical Association*, 113:653-660, 1939.)

[2]Basal Metabolism in Health and Disease, quoted by E. F. DuBois. (*Lea* and *Febiger*, Philadelphia.)

[3]Loc. Cit. Note 2.

a basal level. Breakfast is eaten and work begun. The production now rises 100 to 150 per cent. After lunch with a period of relaxation the heat production falls. So throughout the day, the energy uptake fluctuates widely. Despite these fluctuations the body temperature is guarded so jealously that it does not vary significantly. In view of the great dependence of the poikilothermous animals on heat production to maintain body and cellular temperature, the question naturally arises as to what extent man and the homeothermous animals make use of variations in heat production to accomplish this objective.

Role of Heat Production in Regulation of Body Temperature

It can be seen that, if one is to answer this question, experiments should be conducted with the subject at a basal level of energy expenditure. All the energy developed by the machine is being used to supply its own inherent demands, of which temperature maintenance is a vital one. McConnell, Yaglou and Fulton,[4] working under the auspices of the ASHVE, reported in 1925 on experiments covering basal metabolism before and after exposure to high temperature and various humidities. Their subjects were in the basal state (deprived of food and water for 12 hours) and were lightly clothed. The oxygen consumption was measured in the comfortable primary room and again in the warm experimental or secondary room. The values were plotted against effective temperature. It was found that below 65 deg ET and above 85 deg ET, the oxygen consumption increased. They found a zone of minimum metabolism between 75 deg ET and 83 deg ET. Above 95 deg ET there was an increase in body temperature. In this zone it is obvious that conditions were not basal and that the subject's metabolism had increased because of the higher temperature of the metabolizing cells. Wiley and Newberg[5] studied one male subject under basal conditions over an effective temperature range of 59.9 to 84.3 deg with a relative humidity of 20 per cent. They found that the heat production was practically constant between 68.7 deg ET and 81.7 deg ET. In 1937, Hardy and DuBois[6] studied nude male subjects in a calorimeter. Since the relative humidities in the calorimeter experiments varied between 22 per cent and 47 per cent with an average of 30 per cent, the effective temperatures have been plotted on the basis of a 30 per cent relative humidity. They found the heat production constant between 67 deg ET (22.7 C) and 78 deg ET (35 C). In the lower ranges studied, the constant heat production was augmented intermittently by chilling. The chilling could be postponed for a time by a voluntary inhibition of the shivering reflex. It could not, however, be prevented in the face of an increasing heat deficit.

It is well understood by all, that chilling may be abolished by active voluntary movements as swinging the arms, walking vigorously, or other similar movements. In 1940, the same investigators[7] reported that between 72.0 deg ET (27 C) and 74.5 deg ET (29 C), two out of three female subjects showed a drop of metabolism of 14 per cent below that of men. In this respect women would seem to differ from men. In 1938, Hick, Keeton and Glickman[8] reported studies on four hospital normal female subjects, clothed in light cotton pajamas. No significant changes were noted in oxygen consumption between 66.0 and 85 deg ET. When the rectal temperature rose indicating a retention of heat, the basal production also increased. Similar studies were made in 1929 at a somewhat higher metabolic level by Houghten, Teague, Miller and Yant.[9] In these the subjects were allowed to have their usual breakfast and lunch. The experiments were begun at 2 p. m. The subjects were seated most of the time, but were allowed some latitude in their movements. Their metabolism was to be regarded as a standard one, which by calculation was adjusted to a level 36 per cent above basal requirements. They were exposed to varying ranges of relative humidity (20, 45, 70 and 95 per cent), in still air and in air velocities of 235 and 385 fpm. The heat production was constant within the range of 66.7 and 83.7 deg ET. Winslow, Herrington and Gagge[10] reported studies on two subjects, unclothed and in the semi-reclining position, who had eaten a light breakfast or light luncheon 1 to 1.5 hours previously. The metabolism was characterized as *standard* but not basal. The values for Subject 1 were 16 per cent and for Subject 2, 29 per cent above the basal level. The heat production was found to remain approximately constant over the ranges of *operative temperatures* (64.4 to 105.8 deg) studied. Although the relative humidity varied between 40 and 50 per cent the environmental operative temperatures cannot be expressed as effective temperatures in all cases, because there were large experimental differences between the temperature of the walls and the surrounding air.

Observations of various investigators on the environmental range within which the metabolism is constant are summarized in Table 1.

One should at this point distinguish between basal heat production and extra heat produced intermittently by shivering or by voluntary activity. The basal heat production is a function of cell temperature, concentration of thyroxin and other calorigenic hormones. This is an unconscious source of heat and rarely reaches the attention of the individual unless there are gross abnormalities. From the evidence cited, it is obvious that the body does not accelerate or depress this unconscious type of heat production when extra heat is required. It is a fixed quantity through all the ranges of environmental temperature, in which the cellular temperatures of the body remain constant. When the nude body is exposed to below 74.2 deg ET over a relatively

[4]Basal Metabolism Before and After Exposure to High Temperatures and Various Humidities, by W. J. McConnell, C. P. Yagloglou and W. B. Fulton. (ASHVE TRANSACTIONS, Vol. 31, 1925, p. 123.)

[5]Journal of Clinical Investigation, by F. H. Wiley and L. H. Newberg. (10:689, 1931.)

[6]Regulation of Heat Loss from the Human Body, by J. D. Hardy and E. F. DuBois. (*Proceedings of National Academy of Sciences*, 23:624-631, 1937.)

[7]Difference Between Men and Women in Their Response to Heat and Cold, by J. D. Hardy and E. F. DuBois. (*Proceedings of National Academy of Sciences*, 26:389-398, 1940.)

[8]Physiologic Response of Man to Environmental Temperature, by F. K. Hick, R. W. Keeton and Nathaniel Glickman. (ASHVE TRANSACTIONS, Vol 44, 1938, p. 145.)

[9]Thermal Exchanges Between the Human Body and Its Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant. (*American Journal of Physiology*, 88:386, 1929.)

[10]Physiological Reactions of the Human Body to Varying Environmental Temperatures, by C.-E. A. Winslow, L. P. Herrington and A. P. Gagge. (*The American Journal of Physiology*, 120:1-22, 1937.)

Table 1—The Environmental Ranges of Constant Metabolism

Investigator	Effective Temp. F	Operative Temp.	Remarks
1. McConnell, Yaglou and Fulton	65.0 - 85.0	—	Basal and Lightly Clothed
2. Wiley and Newburgh	68.7 - 81.7	—	Basal and Nude
3. DuBois and Hardy (Men)	67.0 - 81.5	—	Basal and Nude (Did not extend investigations above 81.5 deg)
4. DuBois and Hardy[a] (Women)	67.0 - 72.0	—	Basal and Nude
5. Hick, Keeton and Glickman	66.0 - 85.0	—	Basal and Very Lightly Clothed
6. Houghten, Teague, Miller and Yant	66.7 - 83.7	—	Standard Metabolism = Basal + 36 per cent Normally clothed
7. Winslow, Herrington and Gagge	—	64.4 - 105.8	Standard Metabolism = Basal + 16 per cent and Basal + 29 per cent unclothed

[a] Starting at 72 deg ET the heat production falls and reaches a value 14 to 20 per cent lower at 76.9 deg ET, then remains constant up to 81.5 deg ET.

short period it cools and continues to lose heat to the environment without producing any extra heat until 66 deg ET[11] or lower is reached. At this point there is extra heat produced by shivering. A conscious and uncomfortable method of heat production is called into action. In ET's above 83.7 heat is retained. The temperature of the cells is increased and basal oxidations are increased. This process also is associated with discomfort, although the rise in cellular temperature per se is probably not the cause of the discomfort.

Heat Elimination

As previously noted, heat is produced within the interior of the body and eliminated from the surfaces. It must first be transported to the surfaces. The mechanism involved is largely a physiological one and its discussion will be continued later in the paper.

Once the heat reaches the surfaces, its dissipation is dependent on the physical properties of the environment. This is a physical problem and falls within the realm of the engineer. It may be helpful at this point to return to the analogy of the incubator and its environment. We have the choice of studying the loss of the heat from the incubator, when it is placed in the relatively uniform environment of a room with a controlled temperature, or when it is placed in the non-uniform environment of the outdoors.

Loss of Heat from Body Surfaces

For simplicity, experiments which have been conducted under less complicated thermal environments will be discussed first. Houghten, Teague, Miller and Yant[12] used an experimental room in which the air was relatively still. The room, air, and walls were approximately the same temperature and the humidity was known. The heat production of their subjects as shown in their data was 36 per cent above the basal level. The subjects were clothed. They were able to calculate the total heat loss by measuring the heat produced and adding to this the heat stored in the body positively or negatively as shown by changes in body temperature. They were also able to partition the heat loss due to evaporation, and by difference between this and the total heat loss, that due to radiation plus convection. DuBois and Hardy[13] measured in their calorimeter the total heat loss. They measured separately the heat loss due to evaporation and radiation, and arrived at that due to convection by difference. The heat production was at basal levels. Subjects were both nude and clothed. Their experiments are most important ones, since they give a clear picture of the temperature regulation of man under the simplest experimental conditions. For the nude subject they define a neutral zone extending from 83 F to 88 F (73.2 to 76.9 deg ET)‡ in which the heat production and elimination balance each other with great exactness and ease. There is no progressive cooling of the body, no rise in body temperature indicating storage, and no sweating required to eliminate the heat. The sudden ingestion of cold drinks may push the individual into the cold zone resulting in fall in body temperature. Hot drinks move him into the warm zone and cause sweating to prevent a rise of temperature. When the subject is clothed, the neutral zone extends over 16 F with an extension into the cold zone, and lies between 64.8 and 76 deg ET. With heavier clothing it is obvious that this zone could be extended further in the cold zone.

It is now of interest to examine the comfort zones experimentally determined by F. C. Houghten and C. P. Yaglou[14] and by C. P. Yaglou and Philip Drinker.[15] The average winter comfort zone lies between 63 and 71 deg ET and the average summer zone between 66 and 75 deg ET. Under the conditions of the experiments, the subjects were clothed and were active to the extent that they were seated and exhibited a limited amount of voluntary movements. It is safe to estimate that their metabolism approximated a level of 36 per cent above basal. The note attached to the comfort chart is significant for the limitations under which the chart is applicable:

Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort lines is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores and the like, where the exposure is less than 3 hours.

The limitations are obviously set up with the hope of reducing the environment to an approximately uniform one, and they require that the individual remain in it long enough to come to an equilibrium or a *steady state* to use a term employed by many physiologists. In this respect the conditions of comfort zone experiments approximate those of DuBois and Hardy and allow one to study the two together.

The *neutral zone* of DuBois and Hardy[16] for the clothed subject at basal conditions lies between 64.8 deg ET and 76 deg ET[17] and corresponds very closely to the summer comfort zone 66 deg ET to 75 deg ET. With somewhat heavier cloth-

[11] Loc. Cit. Note 6.
[12] Loc. Cit. Note 9.
[13] Loc. Cit. Note 6.
‡ Or 28 to 31 C.
[14] Determination of the Comfort Zone with Further Verification of Effective Temperature within this Zone, by F. C. Houghten and C. P. Yagloglou. (ASHVE Transactions, Vol. 29, 1923, p. 163.)
[15] The Summer Comfort Zone: Climate and Clothing, by C. P. Yaglou and Philip Drinker. (ASHVE Transactions, Vol. 35, 1929, p. 269.)
[16] Heat Loss from the Body, by E. F. Du Bois. (Harvey Lecture, Dec., 1938, *Bulletin of the New York Academy of Medicine*, Second Series, 15:143-173, 1939.)
[17] 21.2 C to 30.4 C, or 70.1 F to 86.9 F.

ing and a larger heat production it would be easily extended to the lower limits of the winter comfort zone. This can be seen from an experiment on nude subject J. D. H. With an increase of 36 per cent in his heat production, there would be no cooling of his nude body even at 67 deg ET (23 C.). The comfort zone for men stripped to the waist and at rest has been shown by C. P. Yaglou[18] to lie between 66 deg ET and 82 deg ET with an optimal value at 72.5 deg ET. His subjects were semi-nude and at a somewhat higher metabolic level (basal plus 36 per cent) than those of DuBois and Hardy. The findings agree well with the thought that the comfort zone as defined by the Society corresponds closely with the *neutral zone* of DuBois. The difference between the two is attributable largely to the level of heat production and the quantity and nature of the clothing.

The studies of Winslow and associates[19] have been made in a non-uniform environment and in one in which a source of radiant heat plays an important role. For these reasons it is somewhat more difficult to compare them to the experiments of the Society. Their subjects were at a *standard metabolism* somewhat higher than basal. These workers have been able to measure separately all partitions of heat elimination. They have found a zone of *thermal neutrality* 74 and 84 deg operative temperature for clothed subjects and 84 to 87.8 deg operative temperature for nude subjects. The partition of heat over the wide ranges of operative temperature studied are in essential agreement with those reported by DuBois and Hardy. The conclusions with reference to comfort are found in Professor Winslow's report of the Committee on Physiological Reactions, 1939[20] and are quoted as follows:

It should be expected that in the long run the comfort zone must coincide with the area of thermal adjustment with minimum physiological effort, and this adjustment, as noted above, is reached for the clothed subject in a semi-reclining position, at approximately 80 F (26.7 C) operative temperature corresponding to 74 F (23.3 C) effective temperature (with 50 per cent relative humidity).

Table 2—Comparison of Comfort Ranges With Zone of Thermal Neutrality

Investigators	Effective Temperature		Operative Temp.	Remarks
	Optimum Line	Range	Range	
Comfort Zone				
Houghten and Yaglou	66	63 - 71	.....	Winter non-basal; at rest; normally clothed. Men and women
Yaglou and Drinker	71	66 - 75	.....	Summer non-basal; at rest and normally clothed. Men
Yaglou	72.5	66 - 82	.....	Entire year; non-basal; at rest and stripped to waist. Men
Keeton et al	75	74 - 76	.....	Entire year; basal, nude. Steady state (9 hour exposure). Men and women
Zone of Thermal Neutrality—Neutral Zone				
DuBois and Hardy	75	73.2 - 76.9	.....	Basal; nude; men
	71.8	64.8 - 76.0	.....	Basal; clothed; men
Winslow, Herrington and Gagge	.....	.....	84.0 - 87.8	Non-basal; at rest; nude; men
	.....	.....	74 - 84	Non-basal; at rest; clothed; men

During the last two years, numerous experiments have been conducted on male nude subjects who were allowed to sleep in the experimental room over night. In this way they arrived at a steady state of thermal adjustments. The zones within which the temperature had to be maintained were 74 to 76 deg ET. A variation of half a degree above or below these limits evoked sensations of slight warmth or slight coolness.

The limits of the comfort zones as compared with the neutral zone of DuBois and zone of thermal neutrality are found in Table 2. From this table it is evident that the comfort zones as determined from sensations correspond closely to the zones of thermal neutrality as found by calorimetry.

It is quite a tribute to the research vision and technical ability of the group of investigators of the ASHVE that they were able to define a comfort zone based on subjective evidence that has remained an accepted standard and withstood criticism for a period of 17 years. It is of further interest that physiological and bio-physical experimentation did not establish a mechanistic basis for this zone until 12 years after its announcement. Although these studies are not complete, they do indicate that within the comfort zone a most important integration of physiological thermal adjustment occurs.

Transport of Heat to the Surfaces

As previously stated, 75 per cent of the heat produced by the resting subject and probably 85 per cent by the working subject is developed within the muscles. These are located in the interior, so that the heat must be transported to the surface. The application of the physical laws to the transport of heat within the body was begun by Lefèvre[21] in 1911, continued by Burton in 1934,[22] Burton and Bazett in 1936,[23] Winslow and associates in 1937,[24] and Hardy[25] in 1937. Burton has noted that the flow of heat to the surface necessitates the existence of an internal *physiological gradient of temperature.* The flow takes place by the process of conduction across the tissues, and by convection by the blood flow from hotter to cooler parts. Through the studies of Bazett and McGlone[26] some knowledge has been obtained of the temperatures within the body.

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[18]The Comfort Zone for Men at Rest and Stripped to the Waist, by C. P. Yaglou. (*The Journal of Industrial Hygiene,* 9:251-263, 1927.)

[19]The Influence of Clothing on the Physiological Reactions of the Human Body to Varying Environmental Temperatures, by A. P. Gagge, C.-E. A. Winslow and L. P. Herrington. (*The American Journal of Physiology,* 124:30-50, 1938.)

[20]Recent Advances in Physiological Knowledge and Their Bearing on Ventilating Practice, by C.-E. A. Winslow, T. Bedford, E. F. DuBois, R. W. Keeton, A. Missenard, R. R. Sayers and C. Tasker. (Report of ASHVE Research Technical Advisory Committee—ASHVE Transactions, Vol. 45, 1939, p. 111.)

[21]Chaleur Animale et Bioenergetique, by J. Lefèvre. (Masson et Cie, Lib. de *L'Académie de Medécine,* Paris, 1911.)

[22]The Application of the Theory of Heat Flow to the Study of Energy Metabolism, by A. C. Burton. (*Journal of Nutrition,* 7:497-533, 1934.)

[23]A Study of the Average Temperatures of the Tissues, of the Exchanges of Heat and Vasomotor Responses in Man by Means of a Bath Calorimeter, by A. C. Burton and H. C. Bazett. (*The American Journal of Physiology,* 117:36-54, 1936.)

[24]Loc. Cit. Note 10.

[25]Loc. Cit. Note 6.

[26]Temperature Gradients in the Tissues of Man, by H. C. Bazett and B. McGlone. (*American Journal of Physiology,* 82:415-451, 1927.)

For the purposes of analysis, the body may be regarded as a cylinder (Hardy,[27]) with an interior throughout which the heat is generated and an external surface layer with a depth of 2 to 2.5 cm (0.8 to 1.0 in.). The temperature of the interior is, roughly, that of the rectum. It is not, however, always uniform. The addition of new heat in the muscles lying nearer to the surface may cause a local rise in temperature at these points. The surface layer consists of the epidermis beneath which lie the rich vascular beds of the dermis and subcutaneous tissues. Here the arteries break up into smaller arterioles and capillaries. From these zones, the cooled blood is collected in the venules and returned to the interior. Across the small distance of 2 to 2.5 cm with an environmental temperature of 28 C there is a drop of approximately 3.5 C (6.3 F) in temperature.

Conduction of Heat

Burton[28] has noted that between the ranges of 20 to 30 C environmental temperature, there is little or no appreciable change in the resistance of the body to heat flow as shown by the constancy of his *circulation index*. Hardy[29] finds a constant value for the conductance of heat in a nude subject between an air temperature of 28 C and 22 C. Gagge and his associates[30] also find in the nude subject *thermal conductance* at a relatively constant value between 27 C T_0 and 20 C T_0. With a temperature difference of 4.5 C between the interior of the body and the external temperature of the surface, the conductance becomes constant and minimal. These findings all suggest that below an air temperature of 28 C and a skin temperature of 33 C, the transfer of heat across the surface zone can be explained satisfactorily by the physical laws governing conduction of heat.

The conductance of the peripheral tissues is defined by:

$$K = \frac{H}{A(T_R - T_S)}$$

K = Thermal conductance of tissue for depth of a surface zone of approximately 2.2 cm and for the character of tissue found in the average human subject.
H = Heat loss
A = Total surface area of body
T_R = Rectal temperature
T_S = Average skin temperature

The values for K in gram-calories per degree Centigrade per centimeter^2 per second as used by Lefèvre, Burton, Hardy and Winslow are respectively 0.00033, 0.0002, 0.00024, 0.0003 and agree closely with each other. As has been pointed out, these values are comparable to those for leather, paper, and cork. Hence, in the cold environments the surface zone of the body is a good insulator. From a physiological viewpoint, this must mean that a maximal vasoconstriction has occurred, and that we are dealing with bloodless tissues. The tissues are, of course, not bloodless in the sense that they will not bleed when cut. However, the blood flow is so reduced that it does not convect any significant quantities of heat. Male subjects of normal body proportions therefore transfer all of their heat by conduction to the surface with the exception of the heat lost in vaporizing water from the lung surfaces.

It is next of importance to determine whether the changes in the character of the surface zone will influence the skin temperature or the conductance, when the subject is exposed to colder environments. The deposition of fat in the subcutaneous tissues would presumably decrease the tissue conductivity. Water or edema on the other hand should increase it. In the experiments of Winslow[31] the conductance values for the heavy subject (230 lb) showed approximately an average value of 11 kg-calories per square meter per hour. The lighter subject (105 lb) showed values of 13 kg-calories per meter^2 per hour for approximately the same skin temperatures. It is true that the heat production of the heavier subject per square meter was at a somewhat lower level. If, however, heat production is regulated by the necessity of keeping the body machine idling and in a state of preparedness for work at a given temperature level, one can find in this lower conductance value an explanation for t lower heat production. Hardy a DuBois[32] have recently studied thr nude women over a range of 23 27 C environmental temperatur The heat production was the sam as that of men over the same range The skin temperature and conduc tion were lower. Women, as a rul have more fat deposited in the sub cutaneous tissues than men. Th skin of the male rolls easily on th muscles. The women have a dis tinct padding beneath the skin. I a woman with a relatively fat sur face zone and a man with a zone de void of fatty deposits are producing heat at the same rate and are exposed to a cold environment, the female will retain more heat because of the greater resistance of her tissues to the flow of heat (lower conductance values). If she is to maintain a constant rectal temperature she will have to lower her skin temperature to a greater extent so as to produce a larger gradient. She should be able to tolerate a longer exposure to cold before she is forced to produce extra heat to maintain her thermal equilibrium. She would presumably have the lower range of her comfort zone extended below that of a man, just as the man's comfort zone could be extended by the addition of more clothes.

Convection of Heat

Convection of heat is accomplished by the flow of warm blood into the surface zone. One may expect the increased blood flow to decrease the depth of the surface zone and to raise the skin temperature. Both of these effects will reduce conduction. Hence, in zones above 28 deg (neutral zone and the zone of evaporative regulation) conduction values will gradually decrease and be replaced by convection values. The relative magnitude of these values can be appreciated from an analysis of the blood flow of one of our subjects at rest in comfortable and various hot conditions.

It will be noted that the heat loss is divided into storage, conduction, and convection. The storage is figured in the usual manner from the mass, the rise in temperature and the specific heat. The difficulty arises in separating the conduction and convection losses. The water

[27]The Physical Laws of Heat Loss from the Human Body, by J. D. Hardy. (*Proceedings of the National Academy of Sciences*, 23:631-637, 1937.)
[28]Loc. Cit. Note 22.
[29]Loc. Cit. Note 6.
[30]Loc. Cit. Note 19.
[31]Loc. Cit. Note 19.
[32]Loc. Cit. Note 7.

Table 3—Circulatory Adjustments to Hot Environments

Subject J. M.—*Female*

Cond.	Dry-Bulb F	Wet-Bulb F	Heat Production Cal/M²/Hr	Heat Disposal Cal/M²/Hr			Blood Flow Liters/Hr	Cardiac Output Liters/Hr	Per Cent Cardiac Output for Heat Loss	Conductance Cal/M²/Hr/C	Pulse
				Storage	Conduction	Convection					
Comf.	84.0	64.6	36.3	0	24.5	11.8	4.2	144	2.9	12.8	63
Comf.	84.0	61.7	36.8	0	25.1	11.7	4.0	156	2.6	12.7	63
Hot Dry	99.4	65.0	37.3	3.3	9.5	24.5	22.3	168	13.3	30.9	70
Hot Dry	99.4	67.5	36.3	1.4	10.1	24.8	21.2	156	13.6	29.8	74
Hot Dry	99.5	71.6	36.7	1.6	10.4	24.7	20.2	174	11.7	28.8	68
Hot (no fever) Wet	98.7	84.5	35.3	3.4	7.2	24.7	29.7	162	18.3	38.4	74
Hot (fever) Wet	98.8	86.1	38.6	5.2	6.7	26.7	34.2	222	15.4	42.8	75
Hot (fever) Wet	99.0	87.2	37.0	5.2	7.7	24.1	27.1	201	13.5	35.7	74
Hot (fever) Wet	99.5	90.0	42.9	7.7	7.2	28.0	33.8	243	13.9	42.4	87

content of the blood is somewhat higher than that of tissues. However, the osmotic pressures in the two are equal and therefore the conductivities are approximately the same. One can compute the heat loss by conduction through the superficial zone knowing (1) the interior temperature (T_R); (2) the surface temperature (T_S); (3) the conductivity of the superficial 2.2 cm layer of the body ($K = 0.00024$ gm-cal per degree Centigrade per centimeter² per second.) The convection loss due to the blood flow through the surface zone may now be obtained by the difference between the total heat produced and the sum of the storage and conduction.

It will be noted (Table 3) that the conduction decreases by 70 per cent, the convection increases 138 per cent and storage appears as the environmental temperature is changed from a comfortable to a hot wet environment. The blood flow is increased by 5 to 8 times and the per cent of the cardiac output utilized for heat loss also is increased 5 times. As soon as there is significant storage the cardiac output and the pulse are increased. This means that the first adjustment to a hot condition is the increase in the quantity of blood used to convect the heat. When the environmental conditions become more difficult for heat loss, the rate of the circulation is increased. It may be assumed that the peripheral vessels have previously reached a state of maximum dilatation and that further heat loss can be effected only by increasing the rate of blood flow. Physiologists have noted that increase in work is associated with an increased cardiac output and an acceleration of the pulse. Physicians have long been accustomed to measure the smoothness with which the individual adjusts himself to a work level by taking the pulse before and after exercise tests of various types. In many studies made by the Society it has been noted that acceleration of the pulse occurred when the subjects were exposed to thermal stresses.

Blood Volume—Shifting of Blood Mass

The potential capacity of the circulatory bed (arteries, veins and capillaries) is greater than the available blood. This is shown by the appearance of *shock* when the vascular bed is suddenly maximally dilated. The heart fails because it is unable to secure blood to maintain the circulation. Some of the blood channels must be regarded as quiescent reservoirs, which in periods of vasoconstriction contain little or no blood and in periods of vasodilatation contain larger quantities. The reserve capacity of these reservoirs can be further demonstrated by the intravenous injection into a normal subject of 2000 cubic centimeters of fluids without causing any embarrassment. When a subject is exposed to a hot environment some of the deep lying or visceral reservoirs are closed and the peripheral ones are opened. Thus the vital capacity of the lungs was shown[33] to be increased from 10 to 20 per cent on exposure to hot conditions. The quantity of blood in the lungs was less than in cold conditions. Herrin[34] has shown that when a subject is exposed to hot conditions the blood flow through the kidney drops. The counter part of this transfer of blood is shown by the not uncommon sensation of cold after a heavy meal. The blood has now been transferred to the viscera and the peripheral vessels have been constricted. The skin temperature falls and the individual becomes cold. These data indicate the extreme mobility of the circulating blood volume.

Changes in Blood Volume

During the last year the changes in the blood volumes of subjects exposed to hot conditions has been studied by the dye injection method. The subject was placed in the room under comfortable conditions and a blood volume estimation was made. He was then exposed for varying lengths of time to hot conditions and the blood volume was redetermined.

It was found that a number of the subjects showed an increase. This increase seemed to be due to blood coming from the reservoirs. The plasma, the proteins, and the mass of red cells added were quantitatively such as would be expected on this assumption. Apparently, there is a readily available quantity of blood in the storage depôts which enters the circulation when the circulating volume must be expanded.

Under conditions favoring the evaporation of fluids a concentration of plasma volume was noted on a few occasions. However, in many experiments relatively larger

[33] Loc. Cit. Note 8.

[34] R. Herrin, personal communication.

quantities of water (2.5 lb) were lost through the skin without changing the blood volume. This return of the blood volume to its original value was apparently accomplished by a balancing of the water lost from the skin by that absorbed from the tissues. If the exposure to hot conditions is too prolonged then a concentration of the volume occurs such as is seen in subjects who suffer from heat stroke. One is impressed with the zeal with which the blood volume is protected. It is another one of the internal bodily constants the maintenance of which is indicative of a smoothly functioning machine.

Disproportion Between Blood Volume and Circulatory Bed

Last year Keeton and his associates[35] reported experiments which showed the development of a disproportion between blood volume and the circulatory bed induced by extreme degrees of capillary and venous dilatation. If a subject is placed in hot moist conditions where the ability to lose heat is taxed to the utmost, there is a maximal flow of blood through the surface zone. If this subject be suddenly changed from the horizontal to the upright position the veins are unable to contract adequately. The hydrostatic effect allows the blood to accumulate in the dependent extremities. The heart is deprived of blood, the rate is speeded up, and the arterial pressure falls. Simultaneously with this the blood flow through the brain is decreased, the subject becomes weak, dizzy and faints. This effect to a lesser extent is observed rather regularly in many individuals in the hot humid conditions of summer. Here the discrepancy is slight and the effects are chronic. Such subjects may present themselves to a physician for treatment because of fatigue, lassitude and dizziness. This type of discrepancy due to a lack of venous tone, which we have advanced as the explanation for heat exhaustion, is to be sharply distinguished from a discrepancy due to excessive loss of fluids by sweating which is the forerunner of heat stroke.

Dangers Arising from Character of the Environment

Up to this point, the discussion has been directed towards studies attempting to solve the problems of comfort. It is important to briefly consider the manner in which the environment may bring harm to an individual. It is obvious that the potential dangers lie in the hot zones. The vulnerable link will be found in the convection transport of the heat by the circulation. The experiment on work by Hardy and DuBois[36] in a relatively cool environment (68.9 F) showed that there is a large storage of heat when the work is violent. If the environmental conditions are more difficult, less violent work will cause storage. Fleisher, Stacey, Houghten, and Ferderber[37] found that the most significant indices of danger for workers in high effective temperatures were a rise in body temperature (storage) and an increase in pulse rate. If one reverts to the previous discussion of the convection of heat by the circulation, it can be seen that a significant rise in pulse may indicate an increase in cardiac output. If this rise is excessive it means that the output has probably reached its limit. The rise in temperature, of course, is indicative of heat storage. It is obvious that this cannot be continued indefinitely.

These investigators report a drop in the vital capacity in the hotter atmospheres amounting to maximum of 8 per cent. The changes were not regarded as significant. It should be noted that when the heart becomes inefficient and fails to pump forward the blood received from the lungs, the vital capacity falls. Clinicians regularly use this as a test for cardiac function. Hence, it might be worth while studying the vital capacity under the above conditions more closely as a possible index of heart failure and therefore as a danger sign.

The effects of exposure of an individual at rest to high effective temperatures have been studied by McConnell and Houghten[38] and by McConnell, Houghten and Phillips.[39] They attempted to find in changes in the physiological reactions (rectal temperatures, pulse rate, blood pressure) signs of danger to the subject.

The question is often raised as to the danger of entering and leaving air conditioned buildings in the hot humid summer weather. The effect has been described by some writers as *shock-like* in character. It is apparent from the studies which have been reported by the authors that an analysis has been made of the circulatory adjustments as one moves from a steady state in a comfortable environment to a steady state in hot conditions. This analysis is not complete, and will require much more work. When these adjustments are known, it will then be easier to follow the more rapid changes required by the sudden emergence from an air conditioned space on a hot summer day. New experimental methods will doubtless have to be developed to answer this question but the information should be of value to engineers.

The Problem of Comfort

It would be very helpful to have some method of measuring objectively the sensation of comfort. In a previous section of the paper it was shown that the comfort zones agree well with the zone of thermal neutrality which has also been designated the zone of vaso motor control. When the subject, either nude or clothed, passes to the cold side of this zone, a sensation of coolness appears. If the coolness is replaced by a sensation of cold, then the subject recognizes the state as one of discomfort. One should therefore realize that comfort or discomfort is not a sensation, but an affective state applied in this instance to a sensation of cold. In the same manner a given taste in the mouth may be recognized as sour or sweet. In the next breath, the individual describes it as pleasant or unpleasant. Pleasant is not a sensation but is a

[35]The Peripheral Type of Circulatory Failure in Experimental Heat Exhaustion, by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery. (ASHVE Journal Section, *Heating, Piping and Air Conditioning*, January, 1940.)

[36]The Effect of Exercise and Chills on Heat Loss from the Nude Body, by J. D. Hardy, A. T. Milharat and E. F. DuBois. (*Journal of Nutrition*, 16:477-492, 1938.)

[37]Air Conditioning in Industry—Physiological Reactions of Individual Workers to High Effective Temperatures, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber. (ASHVE Transactions, Vol. 45, 1939, p. 59.)

[38]Some Physiological Reactions to High Temperatures and Humidities, by W. J. McConnell and F. C. Houghten. (ASHVE Transactions, Vol. 29, 1923, p. 129.)

[39]Further Study of Physiological Reactions, by W. J. McConnell, F. C. Houghten and F. M. Phillips. (ASHVE Transactions, Vol. 29, 1923, p. 353.)

Table 4—Plasma Volume Increased

Subject and Date	Conditions: Dry-Bulb F	Conditions: Wet-Bulb F	Exposure Time in Minutes	Plasma Vol. (cc)	Per Cent Change	RBC Vol. (cc)	Per Cent Change	Rectal Temp. F	Weight Loss in Grams
C. G. 6-3	Comf.[a] 99.0	71.7	130	3049 3448	+13.1	2485 2731	+ 9.9	98.3 99.4	——
A. M. 9-23	Comf. 99.6	81.5	59	2583 2866	+10.9	2349 2742	+16.7	98.9 99.0	381
F. C. 9-5	Comf. 99.2	75.5	162	2840 3122	+ 9.9	2232 2589	+16.0	97.8 98.5	596
H. C. 6-7	Comf. 98.9	75.7	138	3367 3663	+ 8.8	2468 2855	+15.7	98.4 99.4	——
F. C. 7-26	Comf. 112.5	79.5	216	3380 3572	+ 5.7	2575 2832	+10.0	97.4 98.4	——
H. C. 5-28	Comf. 99.0	68.2	160	3012 3165	+ 5.4	2802 2924	+ 4.4	98.6 99.5	——

[a] Comf. = Dry-bulb 83.5, wet-bulb 67.5.

description of the effect produced on the subject by the taste sensation. Most of the investigators agree and the experiments of Winslow show quite clearly that on the cold border of the comfort zone the skin temperature and presumably the stimulation of the cold spots give rise to the feeling of discomfort.

When one approaches the warm end of the comfort zone the answer to the question is not so obvious. Thus Winslow found an excellent correlation in the clothed subject between the skin temperature and the sensation of *thermal pleasantness*. In the nude subject the correlation with the skin temperature was also good, but it was better with *degree of wettedness*. Here, there are apparently two physiological processes, a sensation of warmth produced by a stimulation of warm-spots, and the secretion of sweat, to which the sensation of unpleasantness can be attributed. Perhaps it will help to say again that discomfort is an affective state and that it may be associated with either of these processes or some other physiological adjustment that occurs simultaneously. From a practical viewpoint, there are many advantages in correlating discomfort with the appearance of sweat or with the degree of wettedness. Anatomically the cold spots (Krause's end bulbs) for the reception of cold sensations are located very close to the surface. The warm spots (Ruffini's end organs) lie deeper in the skin or subcutaneous tissue. They have been shown by Bazett, McGlone, Williams and Lufkin[40] to be the receptors for sensations of warmth. The cold spots are admirably located for stimulation by the environmental air. The warm spots on the other hand are located in the area where marked fluctuations in blood flow occur.

It will now be helpful to consider the problem of why many people are not comfortable in the comfort zone.

The heat production of the individual may be below normal. This can be due to a lack of secretion of the thyroid gland. Such people are notoriously cold in the customary environmental temperatures. They keep the windows closed, wear stockings in bed and fur coats in mild weather. If an individual has eaten poorly, lost weight and become emaciated, his heat production falls to conserve energy. He too suffers from cold. In this group fall elderly people and certain other individuals with unusually active sympathetic nervous systems. All of these will enjoy a warmer environment. They will have their comfort zone moved upward into the warmer temperature ranges.

In any large group of people there are a number who are unusually active. They move around more than usual. Their heat production is increased by voluntary activity. Other individuals will be found who eat heavily and have increased heat productions, due to the food. Finally, there are others in whom the heat production may be elevated because of over-activity of the thyroid gland (goitre). Such individuals are unusually warm in the average comfort zone. For them, comfort is to be found over lower temperature ranges. Women who have more fat in their subcutaneous tissues than men have wider than normal comfort zones with extensions on both ends. Finally, fat men have their comfort zone moved downward into colder environments.

One can now easily appreciate the view that the comfort zone is not one with fixed rigid borders, but a phasic zone with extensions and recessions on either end. In closing, I would like to quote from Bedford:[41]

> The feeling of warmth experienced by a person is not dependent solely on the warmth of his environment: a variety of other factors also affect his state of comfort. Differences in clothing, in muscular activity, in nutrition, age, and general bodily build, and, not least, in acclimatization, all tend to influence the feelings of warmth experienced by different persons in the same environment; and in consequence it often happens that in a room in which most people are comfortable some feel too warm while others are too cool.

[40] Sensation, by H. C. Bazett, B. McGlone, R. G. Williams and H. M. Lufkin. (*Archives of Neurology and Psychiatry*, 27:489-517, 1932.)

[41] The Warmth Factor in Comfort at Work, by T. Bedford. (Report No. 76, H. M. Stationery Office, London, 1936.)

ELLIOTT HARRINGTON HEADS G E AIR CONDITIONING

Elliott Harrington has been named sales manager of the General Electric air conditioning and commercial refrigeration department, with headquarters at Bloomfield, N. J., according to an announcement by John P. Rainbault, manager, which further designates new sales sections and other changes in the Bloomfield organization.

Under the new arrangement he will supervise distribution and policy matters, and under him will operate three separate sales sections. The automatic heating sales section, under L. H. Hobson, will be responsible for the sale of all oil and gas heating sales throughout the country. The cooling equipment sales section, headed by C. M. Rowland, will supervise the sale of water coolers, room coolers, store coolers, refrigerators of the commercial type, air circulators and ventilators. The contractor and industrial sales section, under S. Martin, Jr., will have the responsibility for the sale of all condensing units, evaporators, evaporative condensers, coils and central plant equipment.

The appointment of Frank H. Faust as commercial engineer of the entire department, and that of E. B. McClelland as assistant sales manager, have also been announced.

Fisherman's Wharf, San Francisco

San Francisco Offers Something Different

By N. H. Peterson*

SAN FRANCISCO typifies the real spirit of the old West—friendliness, courtesy, and the charm of romantic and colorful surroundings. This Queen City of the Pacific combines the ultra modern with some of the old world atmosphere. The history of San Francisco makes an exciting story and it offers the visitor glamour, beauty and the phenomenon of climate that varies only 22 deg from the coldest January day to the warmest July day.

The Society members attending the 1941 Semi-Annual Meeting will find that this meeting will not follow conventional lines—it will be different. Visitors are always impressed with the panorama of sea, bay and mountains, as the city is built on 22 hills and each of these rising from the harbor has some historical significance and each one serves as a living monument to the first pioneers, who created a modern city from a Mexican pueblo.

There is something fascinating about San Francisco with its combination of modern office buildings, the noisy cable cars that climb the steep hills without great effort, and descend apparently at break-neck speed, the colorful street corner flower stands, Fisherman's Wharf, Chinatown, the famous Golden Gate Park, the Mission Dolores, Telegraph Hill, Nob Hill, Twin Peaks, the Presidio, and the Golden Gate. These names revive many memories of legends of the old West—the Crockers, the Huntingtons, the Hopkins, the Stanfords, referred to by Mark Twain, Stevenson and the robust characters of Jack London and Bret Harte.

San Francisco is a great shipping center and on its curved water front will be found ships from the South Seas, the Orient, India,

*President, Golden Gate Chapter, ASHVE.

RESERVE

THESE DATES

JUNE 16-20

Round Trip Fares to San Francisco

From	In Coaches	1st Class Intermediate	Lower Berth Tourist[a] Sleeper	1st Class in Pullmans	Lower Berth Pullman	R. T. Airplane[b]
Atlanta	$74.60	$ 91.20	.....	$106.70	$36.80	$235.70
Buffalo	86.10	104.35	.....	120.65	40.45	237.60
Chicago	65.00	74.00	$17.90	90.30	33.10	189.00
Detroit	76.40	90.45	.....	106.75	37.80	213.74
Kansas City	54.40	61.95	14.70	75.60	27.90	169.24
Minneapolis	65.00	74.00	17.90	90.30	33.10	207.64
New Orleans	64.40	73.30	17.90	89.25	29.40	219.70
New York	93.20	123.45	.....	139.75	45.70	269.90
Omaha	54.40	61.95	14.70	75.60	27.90	183.94
St. Louis	61.60	70.10	.....	85.60	31.50	189.00
Washington, D. C.	89.70	116.70	.....	132.20	43.05	251.54

[a]Tourist sleepers are operated only from Chicago, Kansas City and New Orleans.

[b]Berths extra on sleeper planes, scrip rates lower.

PLAN YOUR

PACIFIC COAST

TRIP NOW

South America, Africa, and every other part of the world. From Telegraph Hill in the old days a semaphore signaled the approach of vessels coming through the Golden Gate from the ports of the Seven Seas. From this vantage point the visitor gets a panoramic view of San Francisco Bay, its famous bridges, and the Golden Gate. At Fisherman's Wharf the small fishing boats cluster at anchor, the fishermen mend their nets, and along the sidewalks great steaming boilers cook the freshly caught sea food.

A visit to Chinatown takes one to another world—narrow streets, tiny shops, the odor of incense and spices, ivory dragons and fat Buddhas in the shop windows, merchants in Oriental costumes, and attractive displays of colorful merchandise from all parts of the world. In Chinatown native operas are sung in Cantonese and in the theaters Chinese plays sometimes last a week.

A modern touch is the telephone exchange in Chinatown, where the operators serve 2300 subscribers and put through their calls by name or number. This area with a population of 15,000 is the largest Chinese community outside of China. Only a few steps from Chinatown is the Latin Quarter and its many shops and restaurants run by Spaniards, Mexicans, Italians and Bohemians are always a joy to the gourmets.

One of the show places of San Francisco is Golden Gate Park, a tract of 1013 acres created over 50 years ago by the Scotch horticulturist, John McLaren. In this maze of beautiful gardens, bridle paths, streams, lakes, playgrounds and groves can be seen innumerable varieties of cactus from the Southwest, Oregon fir, New England birch, Vermont maple, palms from the South Seas, and trees and shrubs from almost every country in the world. The Shakespeare Gardens include every flower and plant mentioned in the works of the bard of Avon, and the Japanese Garden was created by the emperor of Japan in the early nineties. In the park are located athletic fields, playgrounds and wild animal paddocks and thousands of varieties of plant life, museums, Temple of Music and the Prayerbook Cross commemorating the first religious service on the Pacific Coast in the English language (held by Sir Francis Drake's chaplain, June 24, 1579, at Drake's Bay, a few miles north of the Golden Gate). Capt. Amundsen's historic little boat, the Gjoa, the first to sail through the Northwest Passage from the Atlantic to the Pacific, in 1908, is also here.

San Francisco is famed for its good food and the mood of the moment will produce any type of dish desired, whether it be Armenian, Danish, Russian or Oriental.

Within 100 miles of San Francisco is a scenic wonderland—with

Horseback riding and cycling in Golden Gate Park

warm seashore beaches, groves of the tallest redwood trees in the world, spouting geysers, snow covered peaks. South from San Francisco is Spanish Monterey, Del Monte; eastward are the thriving cities of Oakland, Berkeley and Alameda; and northward is Jack London's Valley of the Moon.

En route to San Francisco there is Yosemite Park, Lake Tahoe, the Sierra peaks, and the ghost towns of the 'forty-niners who started the gold rush.

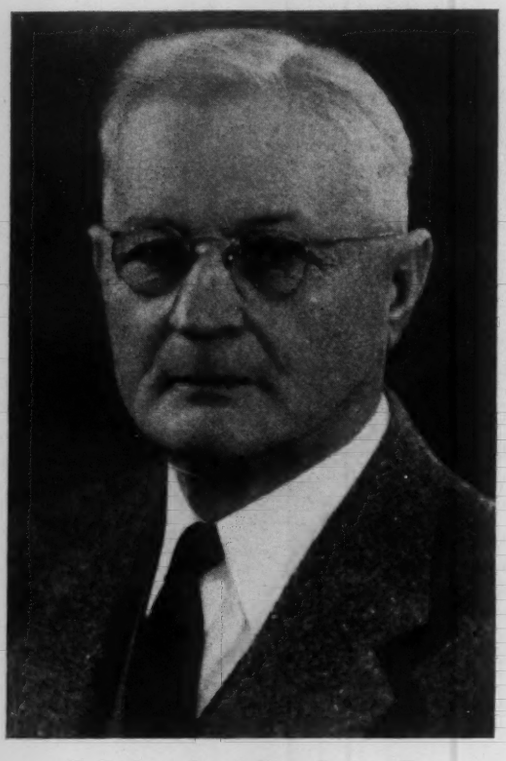
The members of the Society's Golden Gate Chapter are ready to extend a hearty welcome to all who attend the Semi-Annual Meeting 1941 during the week of June 16. A cordial welcome also awaits members of the *Heating, Piping and Air Conditioning Contractors' National Association* and those who will attend the Pacific Heating and Ventilating Exposition.

A fine technical program is promised. There will be notable speakers at the luncheons and banquet and all can be enjoyed at relatively small cost. It is time for every ASHVE member to plan his trip.

Civic Auditorium, San Francisco

The Pacific Heating and Air Conditioning Exposition promises to be the largest event of its kind ever held on the Pacific Coast and C. F. Roth, manager, announces that 70 of the leading manufacturers of heating, ventilating and air conditioning equipment have contracted for space. The displays will be of special interest to engineers, architects, contractors, builders, industrial and operating men, building managers and owners.

The Society will have a demonstration of some of its important research laboratory work and that being conducted in cooperating universities.



F. E. Giesecke, College Station, Tex.
President—1940

Proceedings of the 47th Annual Meeting

W. L. Fleisher, New York, N. Y.
President—1941

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Hotel Muehlebach—January 27-29, 1941—Kansas City, Mo.

KANSAS CITY, MO., welcomed the Society on its 47th Annual Meeting, January 27-29, 1941, at the Hotel Muehlebach, with an attendance beyond expectation, including 246 members, 101 guests and 71 ladies, a total of 418 registered. The Council held a meeting during the afternoon of the 26th and in the evening there was a meeting of the Committee on Research. Eleven Technical Advisory Committees had meetings and two code committees held conferences. During the four technical sessions 15 papers were presented and discussed. Amendments to the By-Laws affecting future dues rates were presented. Delegates from 30 of the 31 chapters of the Society were in attendance at the Chapter Delegates Conference Monday morning.

FIRST SESSION—

Monday, January 27, 2:00 P.M.

The first session of the 47th Annual Meeting of the Society was called to order by Pres. F. E. Giesecke in the ballroom of the Hotel Muehlebach, Kansas City, Mo. President Giesecke announced that the papers would be presented first and the reports would follow.

The opening paper entitled A Comparison of the Weight, Particle Count and Discoloration Methods of Testing Air Filters, by Frank B. Rowley and Richard C. Jordan (complete paper to be published in April 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*) was presented by Professor Rowley. Written discussions were given by Dr. Theodore Hatch, Philadelphia, Pa., Dr. Leonard Greenburg, New York, N. Y., B. G. Heebink and M. H. Kliefoth, both of Madison, Wis., H. C. Murphy, Louisville, Ky., Arthur Nutting, also of Louisville, R. P. Warren, Buffalo, N. Y., and C.-E. A. Winslow, New Haven, Conn. Professor Rowley in closing stated that judging from the discussions, there seemed to be an indication that something was wrong with the present method of rating air filters.

President Giesecke then called upon the next author, D. W. Tomlinson, who presented his paper entitled Comfort in High Altitude Flying (complete paper published in February 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Mr. Tomlinson, in his paper, gave a general idea of some of the problems that arise today, and traced the history of the development of heating and ventilating in airplanes. Written discussions were submitted by the following: Prof. E. O. Eastwood, Seattle, Wash., C. Tasker, Toronto, Ont., Canada, W. A. Russell, Kansas City, Mo., T. H. Urdahl, Washington, D. C., and Dr. B. M. Woods, Berkeley, Calif. In replying to some of the discussion Mr. Tomlinson stated that it was desired to maintain the passenger cabin temperature at about 72 F, and the pilot's cockpit generally runs about 10 deg less, or sometimes a lot less, inasmuch as the nose of the airplane is right out in front and receives a blast of air at 200 mph or better.

President Giesecke then introduced J. F. McIntire, Detroit, who gave his paper on Boiler Testing Codes (complete paper to be published in April 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). To conserve time, the two remaining papers per-

taining to codes were then given as follows: Warm Air Furnace Testing Codes, by F. L. Meyer (complete paper to be published in April 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*), which was presented by the author; and Codes in the Stoker Industry, by E. C. Webb (complete paper to be published in April 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*) also read by the author.

W. L. Fleisher, 1st Vice-President then took the chair, and called for the written discussions which had been submitted for the three papers just presented. A. J. Johnson, Primos, Pa., submitted a written discussion on Mr. McIntire's paper. Those who submitted written discussions on Mr. Meyer's paper were, F. R. Bishop, Detroit, a joint discussion by E. K. Campbell and R. P. Campbell, Kansas City, Mo., Col. W. A. Danielson, Quarry Heights, Canal Zone, J. E. Maynard, Elyria, O., P. A. Mulcey, Primos, Pa., Dr. H. J. Rose, Pittsburgh, Pa., Prof. L. E. Seeley, New Haven, Conn., R. K. Thulman, Washington, D. C., and A. L. Walters, Des Moines, Ia.

Written discussions on Mr. Webb's paper were given by A. J. Johnson, Dr. H. J. Rose, Pittsburgh, and H. R. Satterlee, Joplin, Mo.

R. P. Campbell, in giving his discussion on Mr. Meyer's paper, stated that the object of the discussion was to bring to the attention of the membership of the Society the lack of consideration that has been given to the additional load encountered in intermittent heating. He explained that it results in furnaces being rated at top maximum rating for economical operation to carry nominal load of building, but that a furnace actually operates at considerably higher load—anywhere from 50 to 100 per cent additional for most of the actual operating life. He felt, that should be taken into account, and that work should be done by the Society to recognize those additional loads and see that codes are made that will give the various manufacturers the benefit of that experience and force recognition by the trade, as a whole, for the fact there is an additional load over and above that normally encountered by the calculation of the heat losses.

Mr. Satterlee in commenting on Mr. Webb's paper thought that there should be some means of distinguishing between the fires of the boiler and the fuel burning equipment. He stated that it is known throughout the stoker industry that there are certain types of stokers that will handle certain types of fuel better than others, and in the past he did not believe there had been any distinction. He brought out the fact that one of the detrimental things to the stoker industry has been the fact that most dealers or installation men have thought of a stoker as something that might be plugged in and from then on successful operation would take place. This, he stated, is not true. It is something that must be engineered and must be adapted to the particular boiler. He concluded his remarks by stating that consideration should be given this factor in the future.

Following the written discussions Mr. Fleisher called upon the authors to reply, and also called for oral discussion from the floor. There was considerable discussion from the floor on these three papers. Those who took part were: N. D. Adams, Rochester, Minn., W. H. Junker, Cincinnati, O., J. H. Van Alsburg, Chicago; and Messrs. McIntire, Meyer and Webb answered questions pertaining to their own papers.

President Giesecke resumed the chair and called for the Report of the Tellers, which was submitted by C. S. Pabst, New York, as follows:

Report of Tellers of Election

Ballot—Officers

	For
President—W. L. Fleisher	640
First Vice-President—E. O. Eastwood	673
Second Vice-President—J. H. Walker	673
Treasurer—M. F. Blankin	673

Scattering votes: For M. C. Beman, H. W. Fiedler, E. O. Eastwood for *President;* for J. H. Walker for *First Vice-President;* for J. F. Collins, Jr. for *Treasurer;* and for N. D. Adams for *Member of the Council*

Members of the Council—Three-Year Term

A. P. Kratz	674
W. A. Russell	672
L. P. Saunders	675
C. Tasker	675
Total Ballots Counted	683
Total Ballots Legal	675
Ballots Invalid	8

Ballot—Committee on Research

Three-Year Term

	For
C. M. Ashley	675
M. K. Fahnestock	675
H. King McCain	675
F. C. McIntosh	674
T. H. Urdahl	674
Total Ballots Counted	683
Total Ballots Legal	675
Ballots Invalid	8

BOARD OF TELLERS,
C. S. PABST, *Chairman.*
C. H. B. HOTCHKISS.
J. F. KERN, JR.

President Giesecke then called for the Report of the Finance Committee which was given by E. N. McDonnell in the absence of A. J. Offner, as follows:

Report of the Finance Committee

The following is the financial report for the year of 1940. As last year, your Finance Committee is again pleased to report Society finances as sound and in an excellent condition.

As required by the By-Laws, the accounts of the Society have been audited by a designated certified Public Accountant. The balance sheet and budget comparison prepared by Tusa & La Bella is a part of this report.

The balance sheet for 1940 shows that the net assets of the Society, including Research, amount to $152,943.76; of this total there is $68,960.94 in the operating and reserve accounts and $26,510.48 in the Endowment Funds in cash or invested in securities of the United States Government. Comparing the total income and expenditure of the Society during the past year with the estimated figures as set up in the Budget adopted by the Council at the start of the year, it is found that the income was in excess of the estimate by $5,569.62, while expenses were $1,559.06 less than Budget provisions. The operation of general

Society activities shows a loss for the year of $147.13, but with the surplus from THE GUIDE and editorial contracts, after deduction of reasonable reserves, leaves an addition to the General Fund amounting to $7,128.68. Research activities had an excess of $553.61 in income over current expense.

Subject to the requirements of the Constitution, 40 per cent of the dues, collected from Members and Associates and amounting to $16,402.20 was turned over to the Committee on Research. In addition to this amount the Council appropriated $5,000.00 making a total of $21,402.20 contributed by the Society during 1940 for Research work. The total amount spent in Research during 1940 was $51,386.67 which amount, in addition to Society contributions, also includes earmarked and unearmarked contributions and contracts. A detailed financial statement of the Committee on Research will be presented by the Chairman of that Committee.

During the past year the Finance Committee, with Council approval, has invested $7,500.00, the maximum permitted by law, in U. S. Savings Bonds of $10,000.00 par value at maturity date. This was added to the Endowment Fund not only to strengthen this fund but also to bring it closer to Constitution requirements.

Your Committee has during the past year carefully watched the income and soundness of our present investments. It recommends that surplus funds be retained in Savings Bank accounts, pending an opportune time for sound and legal investments.

Respectfully submitted,

FINANCE COMMITTEE,
A. J. OFFNER, *Chairman.*
E. O. EASTWOOD.
E. N. MCDONNELL.

Tusa & La Bella
Certified Public Accountants
55 Liberty St., New York

January 20, 1941.

American Society of Heating and
Ventilating Engineers,
51 Madison Ave.,
New York, N. Y.

Gentlemen:

Pursuant to your request, we made an examination of the books of account and records of the American Society of Heating and Ventilating Engineers—New York, N. Y. and the Research Fund for the calendar year ended December 31, 1940 and submit herewith our report.

The work covered a verification of the Assets and Liabilities as of the date previously stated and a review of the operating accounts for the year ended December 31, 1940. For the period recorded cash receipts were traced into the depositories; the cancelled bank vouchers were inspected and compared with the cash records and the dues income was accounted for.

Submitted herewith is a balance sheet showing the financial condition of the Society on December 31, 1940 and your attention is directed to the following comments thereon:

CASH

Cash on Deposit was verified by direct communication with the banks and reconcilement of the amounts reported to us with the balances shown by the books of the Society.

The petty cash kept in the New York office was verified by count.

MARKETABLE SECURITIES

There is attached hereto a schedule of negotiable bonds which were verified by direct communication with the Bankers Trust Company where same are deposited for safekeeping. No adjustment has been made of the $3,192.71 shrinkage in the market value of these securities, same being included in the attached Balance Sheet at cost.

ACCOUNTS RECEIVABLE

A list of the Membership Dues Receivable as of December 31, 1940 furnished to us by the management was checked to the individual ledger cards and found in agreement with the general ledger control. The unpaid dues may be summarized as follows:

Dues billed in 1940	$ 6,695.12
Dues billed in 1939	401.45
Dues billed in prior years	3,943.56
TOTAL	$11,040.13

Amounts due from GUIDE advertisers and other accounts Receivable were verified by trial balance of the individual ledger accounts which were found in agreement with the general ledger control.

After charging off $5,618.69 in uncollectible dues per Council authorization we have increased the reserve for dues doubtful of collection by $1,394.14. The adjusted reserves now shown on the attached balance sheet in our opinion are ample to cover any probable losses from future realization.

INVENTORIES

Items appearing under this caption are based upon quantities submitted by the management and computations made by us. The TRANSACTIONS inventory priced at cost may be summarized as follows:

Prior years	$1,750.00
1935-1936	70.95
1937-1938	377.62
1939	604.24
TOTAL	$2,802.81

FURNITURE, FIXTURES AND LIBRARY

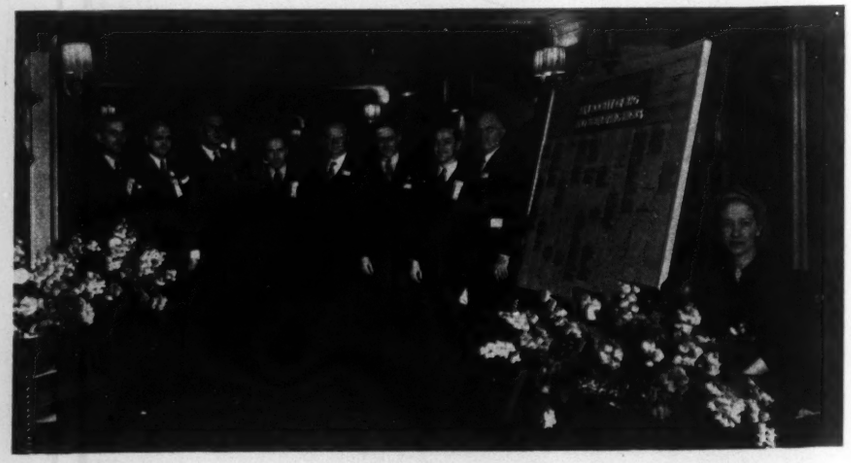
Furniture, Fixtures and Library are shown herein at the book values without appraisal by us; we did, however, provide for depreciation of furniture and fixtures at the rate of ten (10%) per cent per annum.

ACCOUNTS PAYABLE

On December 31, 1940 there remained unpaid invoices amounting to $11,219.29 which included the sum of $10,403.70 estimated by the management necessary to complete and make the first mailing of the 1941 GUIDE.

PAYABLE TO RESEARCH FUND

The amounts due the research fund representing 40% of Members and Associates dues were determined from computations made by us in accordance with *Section* 5, Article 3 of the By-Laws.



Standing—Left to right: E. M. Jolley, Secretary Kansas City Chapter; John Arthur, General Chairman of Arrangements; Gustave Nottberg, Vice-President Kansas City Chapter; W. L. Cassell, President Kansas City Chapter; Dr. F. E. Giesecke, President; W. L. Fleisher, President-Elect; R. P. Campbell, Treasurer, Kansas City Chapter; E. O. Eastwood, 1st Vice-President-Elect

ACCRUED ACCOUNTS

Additional compensation to the secretary and the clerical staff of the Society has been computed in accordance with the instructions of the Finance Committee.

DEFERRED INCOME

Members' prepaid dues were ascertained by trial balance of the individual ledger cards. Prepaid dues from proposed members were verified from inspection of the applications found on file.

GENERAL FUND

There is attached hereto a schedule showing the changes that have occurred in the General Fund during the calendar year 1940.

SPECIFIC FUNDS

The specific funds are shown in the attached Balance Sheet after adjustment for interest earned.

The Balance Sheet and schedules showing the operations of the Research Fund are annexed hereto, also separate report has been prepared and rendered to the Committee on Research.

OPERATIONS

There are attached hereto statements of Income and Expenses for the calendar year 1940 showing an excess of Expenses over Income from Society activities of $147.13 and a net income of $7,275.81 from GUIDE operations. In the preparation of these statements 30 per cent of the salaries and office expenses have been allocated to GUIDE operations.

Respectfully submitted,

TUSA & LA BELLA,
Certified Public Accountants.

BALANCE SHEET

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
New York, N. Y.

December 31, 1940

ASSETS

SOCIETY			
CASH			
On deposit		$37,999.95	
On hand		100.00	
Out for collection		90.00	
In closed banks		418.97	$ 38,608.92
RESERVE FUNDS			
On deposit			$ 11,169.29
INVESTMENTS (AT COST)			
Securities (Market value $19,479.17)		$19,178.23	
Add: Accrued interest		4.50	$ 19,182.73
ACCOUNTS RECEIVABLE			
Membership dues	$11,040.13		
Less: Reserve for doubtful	7,572.14	$ 3,467.99	
Advertisers and sundry debtors	$31,665.51		
Less: Reserve for doubtful	1,291.37	30,374.14	33,842.13
INVENTORIES			
TRANSACTIONS—Copies		$ 2,802.81	
TRANSACTIONS—Paper		548.00	
Emblems and certificate frames		71.14	
Stationery		39.30	$ 3,461.25
PERMANENT			
Library		$ 300.00	
Furniture and fixtures	$ 2,321.71		
Less: Reserve for depreciation	700.19	1,621.52	1,921.52
TOTAL ASSETS			$108,185.84
SPECIFIC FUNDS			
ENDOWMENT FUND			
Cash on deposit		$ 6,772.14	
Securities at cost (market value $16,133.34)	$19,626.99		
Add: Accrued interest	111.35	$19,738.34	$ 26,510.48
F. PAUL ANDERSON AWARD FUND			
Cash on deposit			1,145.82
			$135,842.14

LIABILITIES AND GENERAL FUND

SOCIETY			
ACCOUNTS PAYABLE		$11,219.29	
PAYABLE TO RESEARCH FUND			
On dues as and when collected		4,232.77	
ACCRUED ACCOUNTS			
Compensation—Secretary and staff		3,252.55	
RESERVE FOR PUBLICATION			
TRANSACTIONS—Volume 46		3,900.00	
DEFERRED INCOME			
Prepaid dues—Members	$ 444.35		
Prepaid dues—Proposed members	244.72	689.07	
TOTAL LIABILITIES			$ 23,293.68
GENERAL FUND			
Society			$ 84,892.16
TOTAL LIABILITIES AND GENERAL FUND			$108,185.84
SPECIFIC FUNDS			
ENDOWMENT FUND			
Principal		$24,063.28	
Unexpended income		2,447.20	$ 26,510.48
F. PAUL ANDERSON AWARD FUND			
Principal		$ 1,000.00	
Unexpended income		145.82	$ 1,145.82
			$135,842.14

NOTE "A": This Balance Sheet is subject to the comments contained in the letter attached to and forming a part of this report.

BUDGET COMPARISON

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
New York, N. Y.

For the Calendar Year Ended December 31, 1940

	Actual	Budget Provision	Increases Decreases
Income:			
Initiation fees	$ 1,875.00	$ 1,500.00	$ 375.00
Dues	28,879.29	25,000.00	3,879.29
Editorial contracts	17,050.79	16,000.00	1,050.79
Profit—Emblems and certificate frames	75.61	100.00	24.39
Profit—Reprints and books	255.89	100.00	155.89
Sales of TRANSACTIONS	967.46	500.00	1,467.46
Interest—Savings accounts and securities	1,353.71	1,300.00	53.71
GUIDE advertising	28,848.81	26,000.00	2,848.81
GUIDE sales	18,697.98	20,000.00	1,302.02
	$96,069.62	$90,500.00	$ 5,569.62
Expenses:			
General Society Activities:			
Meetings	$ 1,617.36	$ 2,000.00	$ 382.64
Chapter allowances	1,150.00	1,200.00	50.00
Promotion expense	.....	500.00	500.00
Speakers Bureau	1,288.76	1,200.00	88.76
Subscriptions—HPAC	6,406.34	6,500.00	93.66
Postage	1,738.70	2,000.00	261.30
Rent and light	3,623.73	3,800.00	176.27
TRANSACTIONS	3,900.00	3,900.00	.....
Codes	.....	500.00	500.00
Salaries—Secretary and staff	17,907.00	18,000.00	93.00
General printing	471.83	600.00	128.17
Membership certificates	188.90	500.00	311.10
President's fund	1,757.66	1,800.00	42.34
Secretary's travel	1,259.15	1,300.00	40.85
Council and chapter delegates travel	3,447.43	3,500.00	52.57
Bank charges	461.34	100.00	361.34
Multigraphing	478.93	350.00	128.93
Telephone	662.55	700.00	37.45
Telegraph	209.23	300.00	90.77
Professional services	850.00	1,000.00	150.00
General office expense	496.94	600.00	103.06
Office supplies	466.87	650.00	183.13
Furniture and fixtures	428.24	240.00	188.24
Reserve for additional compensation	2,661.19	2,800.00	138.81
Special appropriation	5,188.50	760.00	4,428.50
	$56,660.65	$54,800.00	$ 1,860.65

GUIDE Expenses:			
Copy sales promotion	$ 2,906.01	$ 3,000.00	$ 93.99
Express and mailing	3,440.76	4,000.00	559.24
Advertising sales promotion	1,405.07	3,000.00	1,594.93
Editorial and advertising salaries	5,591.36	5,500.00	91.36
Committee expense (chairmen's fund)	514.76	500.00	14.76
Printing and binding	13,218.90	14,000.00	781.10
Paper	3,184.29	4,000.00	815.71
Cuts and drawings	619.14	500.00	119.14
Yearbook	1,400.00	1,200.00	200.00
	$32,280.29	$35,700.00	$ 3,419.71
TOTALS	$88,940.94	$90,500.00	$ 1,559.06

BALANCE SHEET

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
Research Fund

New York, N. Y.
December 31, 1940

ASSETS

CASH			
ON DEPOSIT			
Treasurer's account—Bankers Trust Co.	$2,973.77		
Secretary's account—Chase National Bank	4,634.44		
Directors account — Forbes National Bank	401.41		
Thrift account—Bank for Savings	3,203.82	$11,213.44	
ON HAND FOR DEPOSIT			
Treasurer's account—Bankers Trust Co.		$ 1,604.53	
ON HAND			
Petty cash—Pittsburgh		16.29	$12,834.26
ACCOUNTS RECEIVABLE			
RESEARCH CONTRACTS			
Navy Department			3,561.75
PERMANENT			
Laboratory equipment			1.00
Total Research Fund assets			$16,397.01
RESEARCH ENDOWMENT FUND			
CASH ON DEPOSIT			
Bank for Savings		$ 536.83	
CASH IN CLOSED BANK			
Bank of U. S. in liquidation		167.78	$ 704.61
			$17,101.62

LIABILITIES AND FUND

DEFERRED INCOME			
Exposition income	$5,033.10		
Summer cooling	2,050.00		
Glass study	792.13		
Air distribution	250.00		
Frictional flow water	190.00		
Radiation and comfort	50.00	$ 8,365.23	
RESEARCH FUND		8,031.78	
Total Research liabilities and fund.			$16,397.01
RESEARCH ENDOWMENT FUND			
Principal		$ 600.00	
Unexpended income		104.61	$ 704.61
			$17,101.62

NOTE "A": This balance sheet is subject to the comments contained in the letter attached to and forming a part of this report.

NOTE "B": The Research Fund as at December 31, 1940, had a contingent asset amounting to $4,232.77 arising from 40% of the Society's members and associates dues, payable upon collection by the latter.

BUDGET COMPARISON

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
Research Fund

New York, N. Y.

For the Calendar Year Ended December 31, 1940

	Actual	Budget Provision	Increases Decreases
Income:			
ASHVE dues	$16,437.46	$15,000.00	$ 1,437.46
ASHVE appropriation	5,000.00	5,000.00	.....
Exposition	5,000.00	5,000.00	.....
Interest	55.43	60.00	4.57
Contributions:			
General	2,375.00	2,500.00	125.00
Earmarked:			
Navy contract	10,000.00	10,000.00	.....
Glass	846.83	846.83	.....
Radiation and comfort (Pierce)	2,017.69	2,017.69	.....
Corrosion	500.00	500.00	.....
Convector	400.00	400.00	.....
Comfort and low humidity	3,250.00	3,250.00	.....
Air distribution	750.00	750.00	.....
	$46,632.41	$45,324.52	$ 1,307.89
Unbudgeted:			
Floor losses	$ 1,000.00	.....	$ 1,000.00
Frictional flow water	650.00	.....	650.00
Glass (additional)	407.87	.....	407.87
Summer cooling	1,250.00	.....	1,250.00
Window shading	2,000.00	.....	2,000.00
	$ 5,307.87	.....	$ 5,307.87
	$51,940.28	$45,324.52	$ 6,615.76
Expenses:			
Cooperative Research:			
Institutions	$11,977.60	$12,500.00	$ 522.40
U. S. Navy	10,000.00	8,612.60	1,387.40
Glass requirements	846.83	846.83	.....
Radiation and comfort	2,100.25	2,017.69	82.56
Comfort low humidity	3,394.69	3,250.00	144.69
Pittsburgh Laboratory:			
Duct friction	4,613.09	5,000.00	386.91
Cooling load	2,911.53	2,700.00	211.53
Heating load	2,781.76	2,700.00	81.76
A.C. industry	3,082.61	3,000.00	82.61
Local cooling	2,105.78	2,400.00	294.22
	$43,814.14	$43,027.12	$ 787.02
Unbudgeted:			
Floor losses	$ 1,385.05	.....	$ 1,385.05
Frictional flow water	650.00	.....	650.00
Glass (additional)	407.87	.....	407.87
Summer cooling	1,690.00	.....	1,690.00
Window shading	3,107.09	.....	3,107.09
Color sensation	332.52	.....	332.52
	$ 7,572.53	.....	$ 7,572.53
	$51,386.67	$43,027.12	$ 8,359.55

The Report of the Guide Publication Committee was given by the Chairman as follows:

Report of Guide Publication Committee

Press work on the 1941 edition of THE GUIDE is nearing completion and copies will soon be distributed.

In accordance with established policy, a considerable part of the text material has been reviewed or rewritten by authors who were selected because they were acknowledged authorities on the subjects covered. Much old material has been retained and that covering new developments has been added.

There are 46 chapters as in the previous edition but there has been some rearrangement of material. Chapter 23, Cooling, Dehumidification and Dehydration and Chapter 24, Refrigeration

are new chapters containing material formerly in two old chapters plus a considerable amount of new information. The chapters have been rearranged and grouped into seven sections to make a more logical arrangement and to better correlate the Technical Data Section and the Catalog Data Section. It was necessary to revise the numbering by which some of the first chapters have been known for several years but the advantages of the change appear to be justified.

In all, 21 chapters were reviewed or rewritten this year and minor changes were made in other chapters. Chapter 1, Thermodynamics of Air and Water Mixtures, is entirely new. Since the treatment is new, it is given in greater detail than is customary in the GUIDE, for the benefit of readers who may wish to follow such a detailed discussion. A new chart, Mollier Diagram for Moist Air, is presented for use in analyzing air conditioning processes. It is printed on the sheet containing the Bulkeley Psychrometric Chart and will be found in the pocket attached to the back cover.

Other chapters which have been rewritten or revised are: Heat Transmission Coefficients and Tables, Heating Load, Cooling Load, Chimneys and Draft Calculations, Automatic Fuel Burning Equipment, Heat and Fuel Utilization, Central Systems for Comfort Air Conditioning, Spray Equipment, Fans, Air Distribution, Air Duct Design, Sound Control, Automatic Control, Air Conditioning in the Treatment of Disease, Transportation Air Conditioning, Industrial Air Conditioning, Electric Heating and Terminology.

The Catalog Data Section contains much useful information which has been supplied by the various manufacturers. The equipment has been grouped in sub-divisions for convenience in locating data.

There is an increase of 22 pages in THE GUIDE this year but thin paper has again been used so that the thickness of the book is approximately the same as for the previous edition. The comparison with the 1940 edition is as follows:

	1941	1940
Technical Data Section	808 pp.	792 pp.
Advertising Space	260 pp.	244 pp.
Total	1206 pp.	1184 pp.
Number of copies	11,000 copies	10,500 copies
Sales	$20,000.00	$18,697.98
Advertising Revenue	$29,979.25	$28,010

The Committee held three meetings, two in New York and one in Washington. The expenses of the Committee were kept within the budget of $500.00 provided by the Council.

The Committee is appreciative of the response of the membership to the request which it made for suggestions for THE GUIDE. Many valuable suggestions were received. All were carefully considered and as many as possible were incorporated in this edition.

The text is made up of the contributions of many individuals over a period of years. To those who have contributed to previous editions the material which makes up the greater part of the Technical Data Section, the Committee acknowledges its indebtedness. Thanks is particularly due to the twenty-four men who have contributed the new material which appears in this edition and whose names are listed in the preface.

The Committee on Research, the ASHVE Research Laboratory and several individuals have been particularly helpful. They have provided much new and needed information. Technical papers presented before the Society have also been the source of useful material.

The cooperation of A. V. Hutchinson was much appreciated and I want to especially thank John James for his part in the production of THE GUIDE. He has handled much of the detail of its preparation. The fact that THE GUIDE has been completed and will be out on time is largely due to his efforts. The loyal cooperation of Mr. James was of the utmost assistance. I also want to thank the other members of the Committee who worked faithfully to make the 19th edition of THE GUIDE a success.

Respectfully submitted,
S. S. SANFORD, *Chairman*,
Guide Publication Committee.

The Report of the Council is given as follows:

Report of Council

Since the last Annual Meeting five meetings of the Council were held, at Cleveland, Chicago, Washington, D.C., Houston and Kansas City.

At the Cleveland Meeting President Giesecke announced the personnel of Council and special committees which have served during the past year. Depositories for Society funds were selected and a Certified Public Accountant was appointed to audit the Society's books.

The Council authorized a special appropriation of $5,000.00 for Research and approved the General Society Budget for the calendar year 1940 on the basis of estimated income to $90,500.00 and expenditures of a similar amount. Payment of round-trip railroad fares for Chapter Delegates to the Annual Meeting was approved and authorization given for similar payment to Council Members who attended the Annual and Semi-Annual Meetings held during the calendar year.

Meeting invitations from several chapters were considered and the Council accepted the invitation of the Kansas City Chapter for the 47th Annual Meeting and decided upon San Francisco as the meeting place for the Semi-Annual Meeting 1941 and authorized the sponsorship of a Pacific Heating and Air Conditioning Exposition.

Washington, D. C. was selected for the Semi-Annual Meeting 1940 and Houston, Tex., was approved as the meeting place for the Fall Meeting in October 1940.

The technical programs for the 1940 meetings were approved as submitted by the Meetings Committee.

On petition of the Iowa and Nebraska members, charters were granted for the Nebraska Chapter with headquarters at Omaha and the Iowa Chapter with headquarters at Des Moines, to replace the original Iowa-Nebraska Chapter. A charter was granted also for the Connecticut Chapter with headquarters at New Haven.

During the year the Membership Committee revised the booklet on *The Aims and Activities of the Society*.

The Council accepted the recommendations of a special committee on the renewal of the editorial contract for a five-year period.

The Publication Committee was requested to make a detailed study of publication policy. The suggestions of the Meetings Committee for those who prepare and present papers before the Society were approved. Renewal of the lease on headquarters office space for a three-year term was approved.

As requested by the Council the Committee on Constitution and By-Laws offered suggestions for revision of those sections governing membership requirements. Initiation fees, reinstatement fees and dues rates for 1941 were approved and the Exchange Service Plan with *ASRE* was renewed.

A request to solicit advertising by a local chapter to defray the cost of issuing the membership directory was disapproved by the Council.

A guest register was prepared and presented to the Institute of Boiler and Radiator Manufacturers for their newly established IBR Research Home.

The Council took action in accordance with requirements of the Constitution in nominating candidates for election to the Committee on Research who voted on the recommendations of the Committee on Admission and Advancement, approving the election of candidates to membership and acted on the cancellation of membership of those who were in arrears in dues. At

the final meeting of the Council unfinished business was acted upon and resolutions of appreciation for President Giesecke and the retiring Council Members were adopted.

Respectfully submitted,

A. V. HUTCHINSON, *Secretary.*

The Report of the Secretary is presented as follows:

Report of Secretary

The activities of the Society for the year 1940 were equivalent to a business of nearly $150,000 of which over $50,000 represented Research. The various reports of Officers and Committees will show that a year of excellent progress has been recorded.

The headquarters office has had the responsibility of carrying on the routine membership functions, with its innumerable details of elections, changes of addresses, surveys, employment, correspondence and bookkeeping; preparing the monthly JOURNAL, TRANSACTIONS, Vol. 45 and the mechanical production of THE GUIDE, as well as the solicitation of advertising and sale of copies.

Membership applications from 272 were received and the present total membership of 3003 shows a net loss of 142 members. Several unusual factors have been involved this year, namely, difficulty of foreign members in making dues payments with resulting heavy losses, entry of members into military service who have requested temporary suspension of their membership. The offsetting factor has been the higher rate of collection of back dues and the fact that there are fewer now on the rolls in arrears than a year ago.

In a membership survey it is evident that many changes have been made by members and the address records show as many as four changes for one man, within a period of 10 months. The trend may be estimated in the number of address changes that have been recorded this year totalling 1468. To keep the address file up to date is one of the most difficult assignments and at the present time many members are now listed under "mail returned" classification. Sometimes after several weeks or months a member writes from another city and complains about the non-receipt of his publications. To avoid this, full cooperation in sending address changes promptly is essential.

Many members are on national defense projects and it is interesting to note that the average age of our members makes 37 per cent of those in the U. S. eligible under the draft law.

For the Society's three meetings during the year, the headquarters office has cooperated with the Local Committees on Arrangements in publicizing the meetings to members and close cooperation has been carried on with the Meetings, Publication, Finance, Guide, Membership, Research and numerous other special and technical Committees. The Secretary has had the opportunity of visiting 17 of the Society's 31 chapters during the year and all 31 chapters have received an official visit from President Giesecke, or Vice-Presidents Fleisher and Eastwood.

The Speaker's Bureau has been called upon by 27 chapters for the assignment of 44 speakers during the year and because of limited funds it was necessary during the last quarter to enlist the services of volunteers. A number of the Council and committee members offered their services without expense to the chapters or the Society. Because of geographical location it was not possible to provide all chapters with a list of speakers. For the better administration of the Speakers Bureau it would be advisable for the Council to amend some of the rules for the coming year.

Although the work involved in handling the administrative duties of the Society has increased considerably in volume during the past year, it has been possible to meet all demands without increasing the staff as everyone has given full cooperation.

Respectfully submitted,

A. V. HUTCHINSON, *Secretary.*

SECOND SESSION—

Tuesday, January 28, 10:00 A.M.

The second technical session convened at 10:00 a.m. with First Vice-President Fleisher presiding. The first paper presented was the Report of the Committee on Research (complete paper published in January 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*) which was given by its Chairman, A. E. Stacey, Jr.

Following remarks by Mr. Fleisher relative to the research of the Society and to its chairmanship, he called upon President Giesecke, who gave his paper Friction-Heads in Standard Six-Inch Pipe, by President Giesecke and J. S. Hopper as co-author (complete paper published in February 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions were presented by Ferdinand Jehle, Stamford, Conn., and H. A. Lockhart, Des Plaines, Ill. Considerable oral discussion followed in which the following took part, Mr. Van Alsburg, Prof. Axel Marin, Ann Arbor, Mich., N. W. Downes, Kansas City, I. C. Jennings, South Norwalk, Conn., R. E. Moore, Chicago.

The next paper was entitled Radiation as a Factor in the Sensation of Warmth, by F. C. Houghten and his associates, S. B. Gunst and J. Suciu, Jr. (complete paper published in February 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Director Houghten in opening his remarks stated that this paper represents a first step in a new phase of a very old and long investigation. Written discussions were then submitted by F. R. Ellis, Boston, Mass., A. P. Gagge, New Haven, Conn., who submitted his for the Technical Advisory Committee on Instruments, G. P. Nachman, Cleveland, O., A. F. Nass, Pittsburgh, Pa., Dr. C.-E. A. Winslow, New Haven, Conn., and J. C. Fitts, New York. Lieut. Commander R. M. Watt, Washington, D. C., and Mr. Fleisher joined in the oral discussion.

Mr. Fleisher then introduced E. J. Rodee, New Haven, Conn., who presented his paper Operating Results of a Residence Radiant Wall Heating System (complete paper published in January 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions were submitted by T. N. Adlam, New York, C. F. Boester, St. Louis, and Dr. Giesecke, College Station, Tex. An interesting oral discussion followed in which Mr. Fleisher, Mr. Nachman and J. B. Fullman, Pittsburgh, Pa., took part.

THIRD SESSION—

Tuesday, January 28, 2:00 P.M.

The third technical session was held in the ballroom on the Mezzanine of the Muehlebach Hotel, at 2:00 p.m., with E. O. Eastwood, Seattle, Wash., Second Vice-President of the Society, presiding.

Chairman Eastwood called the meeting to order, and asked for the first paper of the third session, entitled Comfort Requirements for Low Humidity Air Conditioning, by F. C. Houghten, H. T. Olson and S. B. Gunst (complete paper published in January 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Mr. Houghten made the presentation after which Mr. Fleisher offered some comment, and

the first written discussion given was by A. B. Newton, Minneapolis. Other written discussions were given by Thomas Chester, New York, E. P. Heckel, Chicago, and J. deB. Shepard, Baltimore, Md. Before Mr. Houghten closed the discussion comments were offered by L. T. Avery, Cleveland, W. F. Ryan, Salina, Kans., and Dr. Winslow.

Chairman Eastwood then introduced Dr. R. W. Keeton, Chicago, who presented the paper The Influence of Physiological Research on Comfort Requirements prepared by himself and his associates, F. K. Hick, Nathaniel Glickman and M. M. Montgomery (complete paper published in March 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*).

The next paper presented was entitled Comfort and Health and Temperature a Mathematical Solution, by W. L. Fleisher and W. L. Fleisher, Jr. (complete paper published in March 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*) and was given by Mr. Fleisher, Jr. Several written discussions were given, which were submitted by Lieut. A. R. Behnke, Jr., U.S.N. (MC), Washington, D. C., Dean J. A. Goff, Philadelphia, Director Houghten, Ellsworth Huntington, New Haven Conn., a joint discussion by A. P. Kratz and A. E. Hershey, Urbana, Ill., H. C. Rentschler, East Orange, N. J., V. L. Sherman, Glen Ellyn, Ill., C. Tasker, Toronto, Ont., Canada, Dr. Renée v. Eulenburg-Wiener, Tomkins Cove, N. Y., and Mr. Gagge, who complimented the authors on their application of the kinetic theory of gases to the problem of Effective Temperature.

Dr. Giesecke, who had resumed the chair, called for the next paper which was given by E. L. Broderick and was entitled Summer Cooling in the Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and Mr. Broderick (complete paper published in December 1940 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions were submitted by Mr. Boester, H. F. Hutzel, Detroit, J. D. Kroeker, Portland, Ore., W. P. Scott, Jr., San Francisco, Calif., F. G. Sedgwick, Minneapolis, Minn., and J. deB. Shepard, Baltimore, Md. Oral comments were given by Prof. M. M. McClure, West Lafayette, Ind., and S. H. Downs, Kalamazoo, Mich., and the discussion was brought to a close by Professor Kratz.

Following various announcements by Chairman Giesecke the third technical session adjourned at 5:15 p.m.

FOURTH SESSION—

Wednesday, January 29, 10:00 A.M.

The fourth and final technical session was held in the Trianon Room, Hotel Muehlebach, and convened at 10:00 a.m. with President Giesecke presiding. He called for the first paper entitled A Laboratory Method for Cyclic Heat Measurements on Walls and Roofs, by F. G. Hechler and E. R. Queer (complete paper published in January 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*) and this was given by Professor Queer. Written discussions were submitted by Col. W. A. Danielson, Quarry Heights, Canal Zone, P. F. McDermott, Manville, N. J., W. T. Miller, West Lafayette, Ind., F. B. Rowley, Minneapolis, Minn., and W. S. Steele, Newark, N. J. Professor McClure read Professor Miller's discussion and expressed his regrets at not being able to attend the meeting.

Chairman Giesecke then announced that the total registration at this meeting was 418, including 246 members, 101 guests and 71 ladies. He then called upon N. D. Adams for the report of the Membership Committee. Mr. Adams, in reporting for the year 1940, expressed his recognition of the splendid cooperation of chapter membership committees and then delivered the report as follows:

Report of Membership Committee

The Membership Committee in reporting for the year 1940, wishes to recognize the splendid cooperation of the Chapter Membership Committees, and the untiring efforts of our Secretary and his assistants.

During the past year we published a pamphlet entitled *The Aims and Activities of the ASHVE*, which was distributed through the Chapters. This was used to inform our present members and help them interest prospective members in the worth-while work of this Society.

We have assisted in the formation of three new Chapters:—Nebraska with headquarters at Omaha; Iowa at Des Moines; and Connecticut at New Haven. The Iowa and Nebraska Chapters were formed by dissolving the old Iowa-Nebraska Chapter, and securing enough new members in each state to form the two separate chapters. This change has made it possible for members in each state to attend more meetings during the year and has increased interest and activities.

The work of the Membership Committee has been handled by dividing the chapters into three groups, western, central and eastern, one member of the committee residing in each section and corresponding with the chapters in his zone.

In obtaining new members during the past year our emphasis has been on quality, rather than quantity. We have been more interested in getting men to join the Society who are first interested in the work of the Society, and who desire to have a part in the service to Society rather than a personal gain. For the calendar year 1940 a total of 274 candidates were elected as follows: Members—97; Associates—105; Juniors—44; and Students—28.

Due to doubtful and economic disturbances during the year we have had an unusually large number of resignations added to those who have been dropped for non-payment of dues. Some of the latter should have been dropped during previous years. The Council accepted 77 resignations, dropped 256 of all grades and 16 were lost by death.

This leaves us with a total membership of 3003 as of December 31, 1940 as compared with 3147 as of December 31, 1939, yet the income from members dues shows an increase over 1939 of $2936.79. We evidently have dispensed with some dead timber, as this represents a more active and interested membership. The present membership status is:

Honorary Member	1
Presidential Members	20
Life Members	56
Members	1628
Associates	884
Juniors	354
Students	60
TOTAL	3003

Your committee has recommended to the Council that the membership committee, because of its importance to the Society welfare be made a three-year three man committee with one new member appointed each year and the third year member to be made Chairman. This would insure a continuity of work.

Respectfully submitted,

MEMBERSHIP COMMITTEE.
E. K. CAMPBELL
T. H. URDAHL
N. D. ADAMS, *Chairman*

Chairman Giesecke announced that the installation of new officers would follow.

New Officers Installed

John F. Hale, Life Member and President of the Society in 1913, conducted the installation. Those inducted into office were, W. L. Fleisher, New York, *President,* E. O. Eastwood, Seattle, Wash., *First Vice-President,* J. H. Walker, Detroit, *Second Vice-President* (who was unable to be present), and M. F. Blankin, Philadelphia, *Treasurer.* The newly elected Council members were, Prof. A. P. Kratz, Urbana, Ill., W. A. Russell, Kansas City, Mo., L. P. Saunders, Lockport, N. Y., and C. Tasker, Toronto, Ont., Canada.

President-elect Fleisher took the chair and his first duty was to introduce S. F. Nicoll, who presented his paper Reheating by Means of Refrigerant Compressor Discharge Gas (complete paper published in December 1940 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Following the presentation of Mr. Nicoll's paper Professor Eastwood took the chair and called for discussion. He felt that the paper was presented so fully and was so intricate, that he desired to express full appreciation to the author for his presentation and the subject matter of the paper.

The final paper of the meeting was Heat Gain Through Western Windows With and Without Shading, by F. C. Houghten and David Shore (complete paper to be published in April 1941 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Mr. Houghten presented the paper, and written discussions were given by C. M. Ashley, Syracuse, N. Y., L. T. Avery, Cleveland, and M. L. Carr, Pittsburgh, Pa., chairman of the Technical Advisory Committee on Air Conditioning Requirements of Glass. Oral discussions were given by W. C. Randall, Detroit, Mich., T. T. Tucker, Atlanta, Ga., J. H. Carter, St. Louis, Mo., R. A. Miller, Pittsburgh, Pa., and G. L. Tuve, Cleveland, O. Mr. Miller raised the question of conductance of heat, and the application of the word *transmission* to the conductance of sensible heat, particularly as it applies to glass. He further stated that radiant heat is never conducted, it is always transmitted, and that sensible heat may be transmitted, perhaps through hot water pipes, but not transmitted through glass. He explained that heat is *conducted* through glass and if the terminology is confused, the subject of the discussion is apt to be confused. Mr. Houghten closed the discussion, pointing out that this paper was a preliminary report, and because of the weather the investigation was limited and in many respects all that was desired during the summer could not be obtained.

Chairman Eastwood turned the chair over to President Fleisher, who called upon A. V. Hutchinson, secretary, to read the present Constitution and the changes suggested are as follows:

ARTICLE C-II—*Section 4*

A member shall be over thirty (30) years of age and shall have more than eight (8) years' experience in the sciences relating to the arts of heating, ventilating or air conditioning. He shall have been in active practice of his profession and in responsible charge of important work for four (4) years, consisting of design, construction, research, development or teaching, and shall be qualified to design or direct such engineering work.

ARTICLE C-II—*Section 5*

A Junior Member shall be a person over twenty (20) and under thirty (30) years of age who has been actively engaged in the sciences relating to the arts of heating, ventilating or air conditioning work for three (3) years. Each successfully completed year in an engineering school may be considered equivalent to one (1) year of such work.

ARTICLE C-III—*Section 4*

When a Student Member discontinues his regular studies in an engineering college or technical school, he shall be transferred to Junior grade, if he has attained its qualifications, unless he has applied for or has been elected to Associate grade. In no case shall the period of Student Membership exceed four (4) years.

President Fleisher, in response to an inquiry from the floor, explained that by these changes in the Constitution it was hoped to open the Society to a larger group, in other words, instead of saying that a man must have had education in heat transfer before he can become a member of the Society, it is set forth that he must have experience in the sciences relating to the arts of heating, ventilating or air conditioning.

Dr. Winslow moved the approval of the changes in the By-Laws and the motion was seconded by Mr. Randall, put to a vote and carried.

E. K. Campbell made a recommendation for the Kansas City Chapter that the dues of the Society be reduced, if possible.

President Fleisher said that the resolutions or recommendations would be put on record and be taken up by the Council. He further explained that the Council is already discussing the question of dues and amendments to the By-Laws for continuing the Council authority to 1945 would go to members prior to the Semi Annual Meeting.

Report of Resolutions Committee

N. D. Adams, chairman of the Resolutions Committee offered the following resolutions:

WHEREAS, the 47th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has been an outstanding success in the City of Kansas City, Mo., January 27-29, 1941,

THEREFORE BE IT RESOLVED THAT an expression of thanks and appreciation be adopted and spread upon the Minutes of the Society and copies thereof be transmitted to each of the persons and agencies which have contributed to make this meeting so enjoyable for the members of the Society, who attended:

To the Kansas City Chapter of the Society and their ladies, who have extended so many courtesies and received us with such gracious hospitality,

To the members of the Committee on Arrangements of Kansas City Chapter for the fine program of entertainment,

To the authors of technical papers for their valuable contributions and discussions,

To the management and staff of the Hotel Muehlebach for their excellent service,

To the Kansas City Visitors and Convention Bureau for its fine cooperation and assistance,

To the Postal Telegraph Co. for its courtesy in furnishing a registration service board,

To the newspapers of Kansas City for their coverage of our sessions and to the trade papers for their excellent publicity and attendance at the meeting,

To the City of Kansas City, TWA, and the various manufacturing concerns, who arranged interesting inspection trips,

To the railroads for their courteous and efficient service,

To Roe Bartle for his inspiring luncheon address and the banquet speaker, Tom Collins, for his entertaining talk,

To the Kansas City Police Quartet for their harmonious musical numbers,

To John Hale and his assistants, who so ably conducted the installation of the new officers, and

To all those who have contributed so much to our pleasure and enjoyment in Kansas City.

Respectfully submitted,

N. D. ADAMS, *Chairman,*
RESOLUTIONS COMMITTEE,
M. F. BLANKIN
E. N. MCDONNELL

Chairman Fleisher thanked Mr. Adams, and Professor Eastwood moved that they be approved. The motion was seconded by Mr. Randall, put to a vote and unanimously carried.

At 12:45 noon the final technical session of the 47th Annual Meeting was adjourned.

Entertainment

Members and ladies who arrived early in Kansas City were received by the local committee on Sunday afternoon for a social hour and at 6:30 a buffet supper was served at the Kansas City Club. The response to the invitation to enjoy the hospitality of the Kansas City Chapter resulted in an attendance of 140.

Monday at noon at the President Hotel, the Kansas City Engineers Club were the hosts for a luncheon meeting and the featured speaker was Dr. F. E. Giesecke, president of ASHVE, whose subject was Factors Affecting the Span of Human Life.

During an afternoon social hour in the Music Room of Muehlebach Hotel a program of sound movies in color was given. During the evening the Past Presidents had their annual dinner and those in attendance were: W. H. Driscoll, Syracuse, N. Y., John Howatt and John F. Hale, Chicago, W. T. Jones, Boston, Mass., J. I. Lyle, Syracuse, J. F. McIntire, Detroit, and F. B. Rowley, Minneapolis, Minn.

The Terrace Grille of the Muehlebach Hotel was the scene of an informal get-together and entertainment on Monday evening and a turkey dinner was enjoyed.

On Monday the ladies had a busy day, with a luncheon at the Kansas City Club and a sightseeing tour through the city, which included an inspection of the Kansas City Museum and a drive through Swope Park.

On Tuesday morning the ladies visited the Nelson Gallery of Art and had luncheon at the Junior League Club, after which they went on a motor tour of the country club district, which includes some of the finest residential developments in the city.

At a get-together luncheon in the Trianon room of the Muehlebach Hotel, members and their guests heard an inspiring talk by H. Roe Bartle, Kansas City attorney. During the afternoon some of the members made inspection trips to the Public Auditorium, City Hall, and TWA hangars and other points of interest.

The annual banquet and dance was held in the ballroom of the Muehlebach Hotel at 7:00 p. m. on Tuesday, and a fine menu, which included Kansas City sirloin steak as the featured dish, was greatly enjoyed by the 275 who attended. W. A. Russell, Kansas City Council member, acted as toastmaster and introduced W. H. Driscoll, who presented Dr. Giesecke with the Past President's emblem. W. L. Fleisher, president-elect, was introduced and briefly expressed his appreciation for the honor conferred upon him. A humorous and entertaining address was made by Tom Collins, columnist, Kansas City Journal. After the banquet the toastmaster concluded the program with the introduction of the Officers and Committee on Arrangements. During the dinner vocal numbers were given by the Kansas City Police Quartet, and after dinner a floor show made an enjoyable interlude before the dancing.

On Wednesday the ladies went on a shopping tour and during the afternoon, following the technical session, members visited various industrial plants of their choice.

MANITOBA MEMBERS HEAR SALES PROMOTION TALK

December 19, 1940. The regular monthly meeting of the Manitoba Chapter of the Society was held at the Fort Garry Hotel, Winnipeg, with Pres. P. L. Charles presiding, and 11 members and one guest in attendance.

The minutes of the previous meeting were read and their adoption moved by G. C. Davis, seconded by R. L. Kent. President Charles reported that he and Mr. Davis had sent 1000 cigarettes to P. H. Foster, who is at present in an R. A. F. Hospital in Scotland, with the best wishes of members of the Manitoba Chapter. A motion was made by F. L. Chester and seconded by William Worton that the same procedure be followed for E. H. Price, who is at present in active service in England. It was unanimously agreed that this matter be taken care of by Mr. Chester and Mr. Worton.

The president then read a letter from the Society requesting that a representative and alternate be nominated to represent the Manitoba Chapter at the Society's Annual Meeting in Kansas City. President Charles was nominated as delegate and Ivan McDonald as alternate.

President Charles read a letter from J. W. O'Neill, president of the Ontario Chapter, suggesting that a regional meeting be held in Toronto, probably in April or May of the coming year, for the benefit of Canadian members of the Society. This is planned in view of some difficulties now experienced in travelling between Canada and the United States. This suggestion was generally approved by members of this chapter, and it was decided that all members should be consulted as to the most suitable time for such a meeting before a definite reply was made to the Ontario Chapter, stating the number who would attend.

The speaker of the evening, G. C. Davis, gave a very interesting talk on sales promotion, customer relations and operation problems of a district heating utility, covering this very wide subject thoroughly, and very beneficially for members of the chapter. It was suggested by President Charles, and unanimously agreed to by all present that a similar discussion by Mr. Davis would prove extremely interesting to members of the Ontario Chapter. The gratitude and thanks of the Society were expressed to Mr. Davis by Mr. Kent.

WISCONSIN MEMBERS MEET WITH REFRIGERATING GROUP

January 20, 1941. The fifth meeting of the 1940-41 season of the Wisconsin Chapter was held at the City Club, in joint session with the *American Society of Refrigerating Engineers,* with an attendance of 61 members and guests.

The usual reading of the minutes was dispensed with, and Pres. A. S. Krenz instructed the secretary to read a letter received from the Secretary of the ASHVE, inviting the members of the Wisconsin Chapter to attend the 47th Annual Meeting in Kansas City, January 27-29, 1941. The secretary also read a special announcement from the President of the Society relative to a resolution passed by the Council waiving the yearly dues for all members of the Society who enter the military or naval forces of the United States for one year of service.

President Krenz then introduced Mr. Barrs of the *ASRE,* under whose auspices this meeting was arranged. D. L. Fiske, secretary of the *ASRE,* was then introduced and addressed the gathering on the growth of various branches of refrigeration. In his talk Mr. Fiske particularly stressed the importance of closer cooperation between the members of the *ASRE* and the ASHVE, inasmuch as it was felt that the interests of both are similar.

Mr. Panlener, chairman of the program committee of the *ASRE* introduced Prof. B. H. Jennings, professor of mechanical engineering, Northwestern Technological Institute, Evanston, Ill., who gave a very interesting talk on panel heating and cooling, which he illustrated with slides.

After a lengthy discussion, and a rising vote of thanks to the speaker, the meeting was adjourned.

GLASS TALK AT IOWA

January 14, 1941. The January meeting of the Iowa Chapter was held at Hotel Kirkwood, Des Moines, and was attended by 45 members and guests.

Pres. R. A. Norman called the meeting to order and asked that the minutes of the November and December meetings be approved as read. A letter from E. K. Campbell, Kansas City, on the subject of attendance at the Society's Annual Meeting in Kansas City, was then read by the secretary. President Norman urged that all who possibly could attend the 47th Annual Meeting of the Society.

President Norman then pointed out that action still had to be taken on the new By-Laws for the Iowa Chapter, and that there was only one suggested change in these new By-Laws covering Article R-4, Section 1, on the subject of dues, which was voted as follows:

Student members shall pay no dues. Dues of new members shall be prorated. If chapter dues accompany the application for membership, the dues will be subject to $1.00 discount.

A. L. Walters then moved that the By-Laws be accepted by the chapter and the vote in favor was unanimous.

President Norman suggested that the meeting in Ames, previously scheduled for April, be held during March instead. The Iowa City meeting originally scheduled for March would then be changed to April.

S. Frank Cox, technical director of the Double Glazing Division, Pittsburgh Plate Glass Co., and J. C. Kohl, Pittsburgh Corning Glass Co., then gave a joint talk on glass blocks and double glazing of windows, followed by an interesting period of discussion, after which the meeting adjourned.

PITTSBURGH APPOINTS NEW COMMITTEES

January 13, 1941. The January meeting of the Pittsburgh Chapter was called to order by Pres. E. C. Smyers in the Marine Room of the Hotel Roosevelt, and the minutes of the December meeting were approved as read.

Following a report by the treasurer, L. S. Maehling, President Smyers announced the following appointments:

Nominating Committee—F. C. McIntosh, *Representative;* J. F. Collins, Jr., *Alternate.*

Chapter Delegates—T. F. Rockwell, *Delegate;* F. C. McIntosh, *Alternate.*

Program Committee—C. M. Humphreys, *Chairman;* F. B. Mahon, H. E. Park, G. W. Penney and R. J. J. Tennant.

Social Committee—R. W. Loucks, *Chairman;* A. F. Nass, C. E. Park, W. H. Reed, R. H. Sweeney and G. L. Waters.

Attendance and Publicity Committee—H. J. Kirkendall, *Chairman;* J. F. Collins, Jr., R. W. Dickson, E. H. Riemeyer, Jr., and P. C. Von Rosenberg.

Membership Committee—P. C. Strauch, *Chairman;* A. R. Borton, M. L. Carr, W. W. Kige, A. F. Metzger and E. S. Tower.

Auditing Committee—C. E. Parks, *Chairman;* P. C. Strauch.

At the request of the President, the secretary read the proposed amendment to the By-Laws.

G. L. Tuve, professor of heat-power engineering, Case School of Applied Science, was the guest of the evening and chose as his subject Educating the Engineer and the Public. After his talk he exhibited a series of slides showing research work at Case on heating and cooling coils and air flow measurements. The members showed a keen interest in Professor Tuve's talk, and a lively discussion followed. Upon motion of Mr. McIntosh a rising vote of thanks was extended the speaker.

MICHIGAN GREETS W. L. FLEISHER

December 16, 1940. The regular December meeting of the Michigan Chapter of the 1940-1941 season was held at Huyler's L'Aiglon in the Fisher Building, Detroit, wth 40 members and guests at dinner and 60 present for the meeting which followed.

The meeting was called to order by Pres. G. H. Tuttle, and the secretary and treasurer read their reports, which were adopted.

S. S. Sanford read Amendment No. 6 to the By-Laws which revised the method to be followed in the annual election of officers. Adoption of this amendment was moved by E. M. Harrigan and seconded by C. F. Mally.

President Tuttle then introduced W. L. Fleisher, First Vice-President of the Society, who spoke on the subject, "Practical Application of Research in Air Conditioning with Practical Reference to its Significance in National Defense Preparation." During the discussion which followed, numerous questions were asked which Mr. Fleisher answered willingly.

AVIATION ATTRACTS BUFFALO MEMBERS

January 13, 1941. The third meeting of the season of the Western New York Chapter was held at the University Club, with 32 members and guests present. Pres. C. A. Gifford thanked the members of the Christmas committee for the services which they performed, and Roswell Farnham reported on the arrangements for the dancing party at the Park Lane.

M. C. Beman gave a short talk on the 47th Annual Meeting in Kansas City, which was followed by the adoption of a resolution that members who enter the military or naval service of the United States for one year of service will retain their membership without payment of chapter dues from the date of entry into service.

A. G. Hapke, Jr., advertising manager, Bell Aircraft Corp., was the speaker of the evening, and his subject was the Bell Airacobra, which he illustrated with pictures. Following Mr. Hapke's interesting talk the meeting was adjourned.

CONDENSATION IN WALLS DISCUSSED AT WESTERN MICHIGAN

January 13, 1941. The January meeting of the Western Michigan Chapter was held at the Rowe Hotel with 78 present at dinner and 122 in attendance at the meeting, which was called to order by Pres. T. D. Stafford. The minutes of the December meeting were read and approved, followed by the report by the treasurer, H. J. Metzger.

President Stafford presented the Past President's Plaque to Karl Ziesse, who made a splendid response, stating that the Chapter had grown considerably since his regime and he was delighted to have been of service to the Chapter in its earlier days. He also mentioned that he intended to be more active in the future.

The speaker of the evening, L. V. Teesdale, Madison, Wis., gave an interesting discussion on condensation in walls, which he illustrated by slides. Mr. Teesdale brought out that most of the problems existed with new houses although occasionally it did occur in an old house, especially after remodeling had taken place. He stated that the troubles are mostly in the Northern States and decrease the further South you go. He further explained that open gas burners were given as one cause, principally in the Southwest. It was also brought out that the higher the inside temperature maintained the worse the problem became. Mr. Teesdale pointed out that published articles on this problem were available by writing the Forest Products Laboratory, Madison, Wis. A general discussion followed, and Prof. L. G. Miller, East Lansing, did a splendid job in leading further discussion, stating that he had never witnessed the forming of ice such as the slides had shown occurring in the Madison area.

One of the principal causes of moisture seemed to be from plaster and those present left the meeting with the thought that heating plants should be operated immediately upon the application of plaster even though this work occurred in the summer. Following the discussion on this very educational topic by Mr. Teesdale, according to Secretary Warren, the meeting adjourned.

DEFENSE PROGRAM ANALYZED AT MINNESOTA

January 6, 1941. The January meeting of the Minnesota Chapter was held at the Coffman Memorial Union on the Campus of the University of Minnesota with 48 members and guests present for the dinner and meeting which followed.

The meeting was called to order by Pres. M. H. Bjerken at 7:15 p. m. and the minutes for the December meeting were approved as read by the secretary.

N. D. Adams discussed the Annual Meeting of the Society in Kansas City, January 27-29, and urged the members to make every effort to attend.

The speaker for the evening was H. J. Miller, director of the Minnesota Resources Commission. Mr. Miller analyzed our defense program and discussed the effect which the present defense program will have on industry. While the defense program needs everyone's support, he stressed the importance of continuing with research despite preparation for defense. He also described the many natural materials that are available to industry in the State of Minnesota. Many of these materials previously brought into the state are now being obtained locally. He explained the work that his department is doing in connection with encouraging various industries in Minnesota. Following Mr. Miller's interesting talk the meeting adjourned at 9:00 p. m.

ONTARIO MEMBERS MEET

January 6, 1941. The regular monthly meeting of the Ontario Chapter was held at the Royal York Hotel, and 49 members and guests were in attendance.

Following dinner, it was moved by C. Tasker and seconded by W. C. Kelly, that the minutes of the previous meeting be accepted as written.

Pres. J. W. O'Neill read a communication from the headquarters office in New York regarding the payment of dues in Canadian funds, and then called upon J. P. Fitzsimons to introduce the speaker of the evening, Harry Dunlop, sales promotion manager, Imperial Oil Co. Mr. Dunlop presented two movies, the first entitled A Safari on Wheels, and the second Friction Fighters, both of which were thoroughly enjoyed, and E. R. Gauley extended a vote of thanks to Mr. Dunlop for his instructive films, which was followed by adjournment.

VARIETY ENTERTAINMENT FOR PHILADELPHIA MEMBERS

January 9, 1941. The annual dinner meeting of the Philadelphia Chapter was held in the Penn Athletic Club, with an excellent dinner served in the Fourth Floor Lounge.

After dinner Pres. C. B. Eastman opened the meeting. The reading of the minutes of the previous meeting was dispensed with, and the meeting was turned over to H. H. Mather, chairman of the meetings committee, who introduced Ernest Dupille. Mr. Dupille entertained with a very humorous discourse, after which the members were entertained by a magician, an exhibition of the latest in ballroom dancing, and several instrumental musical numbers were rendered. According to Secretary Caldwell, the meeting adjourned at 10:00 p. m.

J. J. BLACKMORE, CHARTER MEMBER, DIES AT 84

Joseph J. Blackmore, a Charter and Life Member of the Society died in his 85th year on February 11, 1941, after a brief illness at the home of his daughter, Mrs. David G. Wagner, 1015 East 18th St., Brooklyn, N. Y.

Mr. Blackmore was born November 22, 1856, in Yorkshire, England, and came to Toronto, Canada, as a boy. He was a pioneer in the heating industry and for many years was associated with J. L. Mott Iron Works and on the formation of the United States Radiator Corp., Detroit, Mich., in 1910 he served as Secretary until his retirement in 1915.

Mr. Blackmore was one of the few surviving Charter Members of the Society, having joined in 1895. He was present at the first meeting of the Society held in New York in January, 1895. He served as secretary of the Council from 1896-97 and on the Committee for Uniform Contract and Specifications from 1896 to 1899. He served on the Standards Committee from 1900 to 1906, acting as its chairman in 1905 and 1906. He was on the Board of Governors of the Society in 1904-05, and was elected secretary of the ASHVE in 1914-15. He contributed many papers on steam and hot water heating systems and cast-iron sectional boilers which are included in the various volumes of the Society's TRANSACTIONS, and for the past 10 years has been a Life Member of the Society.

Mr. Blackmore enjoyed golf as his hobby, which he pursued since his retirement, as much of his time was spent in traveling around the world. Since he took to golf at the age of 45 he has kept a record and retained the score cards of his games played on over 800 different golf courses in the United States, South America, Europe, Australia and New Zealand. He played golf at 13,400 feet above sea level in Bolivia and from this extreme he played on the Furnace Creek Course in Death Valley, Calif., 272 feet below sea level. He once made the statement, "I played my first game in Brooklyn in 1902 and my best game when I was past 73."

For the last 20 years Mr. Blackmore has made his home at the Engineers Club, 32 West 40th St., New York, and has spent his winters in Florida where he could enjoy his daily golf game.

The Officers and Council of the Society express their deepest sympathy to his family.

Mr. Blackmore's first wife died in 1890 soon after moving to Newark, N. J., and in 1893 he married Miss Helen Hornblower.

He is survived by five children, three by his first marriage, Mrs. Marie B. Wagner, Brooklyn, N. Y., Mr. Fred H. Blackmore, Birmingham, Mich., a member of the Society, Mr. Clarence F. Blackmore, Flushing, L. I., and two sons by his second marriage, Mr. Theodore H. Blackmore, Allendale, N. J., and Mr. Julian N. Blackmore, East Orange, N. J.; three brothers, George C. Blackmore, Pittsburgh, Pa., who is also a Charter and Life Member of the ASHVE, Edward Blackmore, Winter Haven, Fla., and Lawrence Blackmore, Maplewood, N. J.; nine grandchildren and three great grandchildren.

Funeral services were held for Mr. Blackmore at the Harry T. Pyle Mortuary, Brooklyn, N. Y.

A. W. MOULDER OF GRINNELL CO. DIES

Albert W. Moulder, vice-president, Grinnell Co., Inc., and a member of the Society for a good many years, died on February 11, 1941, at Providence, R. I., after a short illness. Mr. Moulder was born in Adrian, Mich., on December 27, 1888, and acquired his early education in Cleveland, O., graduating from the East High School.

He received his first drafting experience with the McDonald Bros. Co., Cleveland, where he was employed from 1906 to 1909, at which time he joined the Chafer Co., Cleveland, where he remained for one year. He then went with the W. B. Van Sickle Co., Cleveland, as estimator, and from 1911 to 1913 was vice-president and general manager of the American Heating and Ventilating Co. also in Cleveland. He later joined the staff of the General Fire Extinguisher Co., Warren, O., as chief engineer in charge of heating contracts, specializing in steam and hot water heating systems, and in 1919 became department manager. In 1920 he was made chief engineer of the Grinnell Co., of which he became vice-president in 1935.

Mr. Moulder joined the Society nearly 25 years ago and has participated in many of its meetings. He contributed papers to the TRANSACTIONS, and served on numerous technical committees. His experience and counsel will be greatly missed by his many friends and associates in the Society.

The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere sympathy to the surviving members of Mr. Moulder's family.

HARRY BENTZ PASSES IN NEW JERSEY

Harry Bentz, a member of the Society since 1915, and an air conditioning and ventilating engineer until his retirement in 1938, died of heart disease at his home, 18 Holland Terrace, Montclair, N. J., on January 24, 1941, at the age of 75.

Mr. Bentz served for two years as trustee of the Village of Larchmont, N. Y., and was elected to the Larchmont Board in 1906, where he maintained a residence at that time.

After some years devoted to designing air conditioning and ventilating equipment, he organized the Bentz Engineering Corp., Newark, N. J., of which he was president until its dissolution in 1929. After that he was engaged in designing until his retirement. He contributed much to the heating, ventilating and air conditioning profession during his long and active career in the Society.

Surviving are his wife, Mrs. Maude Mayo Bentz; two sons, John Mayo Bentz, Montclair, and Harry Bentz, Westfield, N. J.; a daughter, Mrs. Ruth B. Lamb, Montclair; a sister, Mrs. Mary Miller and a brother, Stuart Bentz, both of Philadelphia. The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their deepest sympathy to his family who survive.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 40 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by March 15, 1941, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADAMS, EUGENE F., Consulting Architectural Engr., Omaha, Nebr.	G. E. Merwin W. R. White	Frederick Organ Henry Kleinkauf
BOYD, R. L., JR., Sales Engr., Houston Lighting & Power Co., Houston, Tex.	A. B. Banowsky C. A. McKinney	R. M. Spencer G. D. Maves
BURRITT, E. E., JR., Sales Engr., Burnham Boiler Corp., Cambridge, Mass.	C. P. Yaglou Philip Drinker	F. R. Ellis H. M. Tarr
CASKEY, L. H., JR., Gen. Mgr., Plbg. and Htg. Contracting, Martinsburg, W. Va. (*Advancement*)	C. M. Humphreys T. F. Rockwell	J. F. Collins, Jr. F. C. McIntosh
CURLEY, ELLIS I., Sales Engr., American Blower Corp., Philadelphia, Pa.	H. B. Prewitt F. H. Buzzard	H. B. Hedges J. W. McElgin
DISTEL, ROBERT E., Mgr., Distel Htg. Equipment Co., Lansing, Mich. (*Advancement*)	F. C. Warren S. W. Todd, Jr.	W. W. Bradfield O. D. Marshall
EHRENZELLER, ADOLPH, Htg. Engr. & Contractor, A. Ehrenzeller, Dorchester, Mass. (*Reinstatement*)	W. T. Jones Alfred Kellogg	R. S. Franklin N. J. H. Shaw
FANNING, ERROLL C., Engr., Atlas Htg. & Vtg. Co., Ltd., San Francisco, Calif.	C. E. Bentley G. M. Simonson	C. L. Peterson J. A. Hill
FRIEND, WALTER F., Mech. Engr., Ebasco Services, Inc., New York, N. Y.	G. E. May C. A. McKinney	F. G. Burns Louis Elliott
FRITZBERG, LAWRENCE H., Asst. to Chief Engr., Aerofin Corp., Syracuse, N. Y. (*Reinstatement*)	A. E. Stacey, Jr. Milner Noble	H. L. Janet Herman Worsham
FURBER, STANLEY L., Sales Engr., Minneapolis-Honeywell Reg. Co., Omaha, Nebr.	Henry Kleinkauf O. J. Ress	Frederick Organ G. E. Merwin
GAEBLER, MILTON R., Sales Dept., York Ice Machinery Corp., St. Louis, Mo.	L. J. DuBois E. F. Weber	R. C. Smith H. O. Mehmken
GORBANDT, EVERETT T., Partner, Crawley-Gorbandt Co., Atlanta, Ga.	S. W. Boyd C. L. Templin	Leo Sudderth, Jr. L. L. Barnes
GRAVES, F. VERNON, Engr. & Sales, Frank A. Leon Co., Washington, D. C. (*Advancement*)	J. E. Axeman William Bornstein	W. E. Kingswell R. H. Feltwell
GUNTON, CHARLES, Sales & Service, Service Htg. Co., Des Moines, Ia.	T. R. Johnson F. E. Triggs	E. H. Danielson M. L. Todd
HARDING, WALTER, Chief Superintending Engr., Air Ministry, London, England.	Edgar Herring Walter Yates	W. L. Swain J. J. Fraser
HUELSMANN, A. G., Supt., The Powers Regulator Co., Cincinnati, O.	G. V. Sutfin L. A. Washington	E. B. Royer W. H. Junker
HUNT, ARTHUR W., Owner, Arthur W. Hunt Htg. & Vtg. Co., Kansas City, Mo.	D. D. Zink A. D. Marston	L. W. Millis T. V. Pellmounter
JORDAN, FRANCIS O., Specification Engr., Albert Kahn, Inc., Detroit, Mich.	W. L. Fleisher R. R. Ferguson	D. L. Fiske (*ASRE*) A. V. Hutchinson
KEMP, GORDON C., Mgr., Htg. Dept., Chatham Malleable & Steel Products, Ltd., Toronto, Ont., Canada.	V. J. Jenkinson H. R. Roth	H. G. Hill H. D. Henion
KENNEDY, WALTER W., Mech. Engr., Barber-Colman Co., Rockford, Ill.	C. J. Braatz D. J. Stewart	P. H. Werner R. P. Dewey
KILLOREN, D. E., Student, Washington University, St. Louis, Mo.	C. E. Hartwein R. J. Tenkonohy	E. H. Ronsick M. F. Carlock
LESER, FREDERICK A., Dist. Mgr., Ilg Elec. Vtg. Co., Washington, D. C. (*Advancement*)	T. H. Urdahl M. F. Blankin	J. M. Frank S. L. Gregg
MATTHIES, LEO A., Student, University of Minnesota, Minneapolis, Minn.	F. B. Rowley R. C. Jordan	A. B. Algren H. M. Betts
PERKINS, ROBERT C., Br. Mgr., Ilg Elec. Vtg. Co., Dallas, Tex. (*Advancement*)	L. C. McClanahan Sidney Pines	J. M. Frank A. G. Sutcliffe
REILLY, PHILIP H., JR., Office Mgr., Htg. Equipment Co., San Francisco, Calif.	G. M. Simonson C. E. Bentley	C. L. Peterson N. H. Peterson
ROBIN, RICHARD C., Owner, Richard C. Robin, Sales & Engrg., Boston, Mass.	C. P. Yaglou Philip Drinker	R. M. Nee H. M. Tarr
ROEDER, WINFIELD, Br. Mgr., American Blower Corp., New Haven, Conn.	L. A. Teasdale C. G. Chapin	Arthur Ritter J. W. Brinton